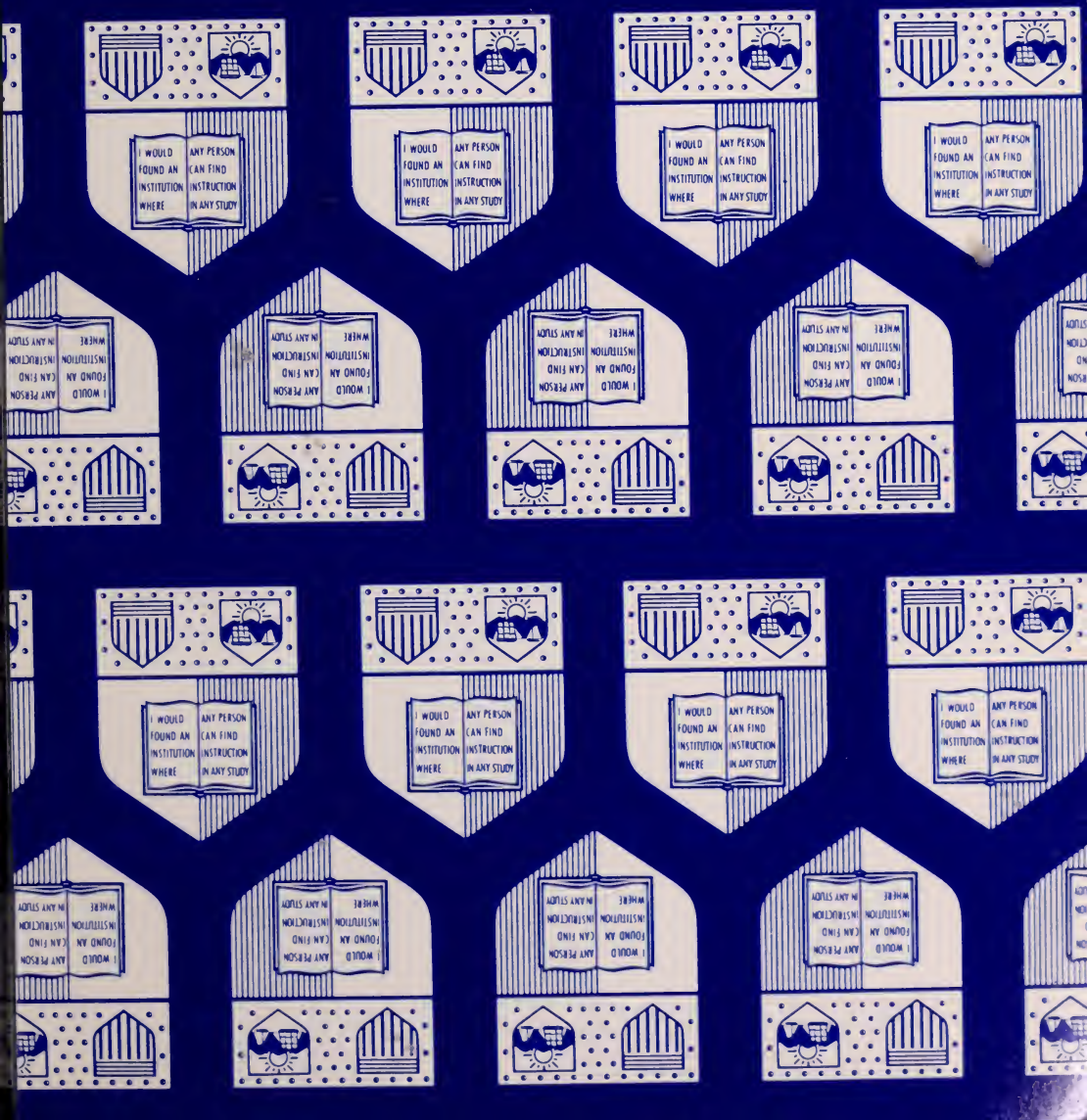
Cornell University Announcements

Graduate School of Medical Sciences



Cornell University

Graduate School of Medical Sciences

1300 York Avenue
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1980-81

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1980-81

Calendar

Fall Semester

Labor Day holiday	Monday, September 1
Registration	Tuesday, September 2-Wednesday, September 3
Orientation, 9:00 a.m.	Wednesday, September 3
Instruction begins for first trimester and fall semester	Thursday, September 4
End of first trimester	Wednesday, November 19
Examinations for first trimester	Thursday, November 20-Wednesday, November 26
Thanksgiving recess	Thursday, November 27 and Friday, November 28
Instruction begins for second trimester	Monday, December 1
Winter recess:	
Instruction suspended, 5:00 p.m.	Friday, December 19
Instruction resumed, 9:00 a.m.	Monday, January 5, 1981
Last day for completing all requirements for January degrees	Friday, January 9
Examination for first semester	Monday, January 19-Friday, January 23
Fall semester ends	Friday, January 23

Spring Semester

Registration	Monday, January 26
Instruction begins for spring semester	Monday, January 26
End of second trimester	Friday, February 20
Examinations for second trimester	Monday, February 23-Friday, March 6
Instruction begins for third trimester	Monday, March 9
Spring recess:	
Instruction suspended, 5:00 p.m.	Friday, April 10
Instruction resumed, 9:00 a.m.	Monday, April 20
Last day for completing all requirements for May degree	Friday, May 8
Memorial Day holiday	Monday, May 25
Commencement, 3:00 p.m	Wednesday, May 27
End of third trimester and spring semester	Friday, May 29
Examinations for third trimester and spring semester	Monday, June 1-Friday, June 5

Summer

Registration for summer research	Monday, June 8
Summer research period begins	Monday, June 8
Last day for completing all requirements for August degrees	Friday, August 14
Summer research period ends	Friday, August 21

Note Courses in the Graduate School of Medical Sciences are either semestral or trimestral The calendar for this school is based primarily on the academic semester but is coordinated as well with the trimestral calendar of the Medical College The dates shown in the calendar are subject to change at any time by official action of Cornell University

In enacting this calendar, the Graduate School of Medical Sciences has scheduled classes on religious holidays. It is the intent of the school that students missing classes due to the observance of religious holidays be given ample opportunity to make up work

Announcement

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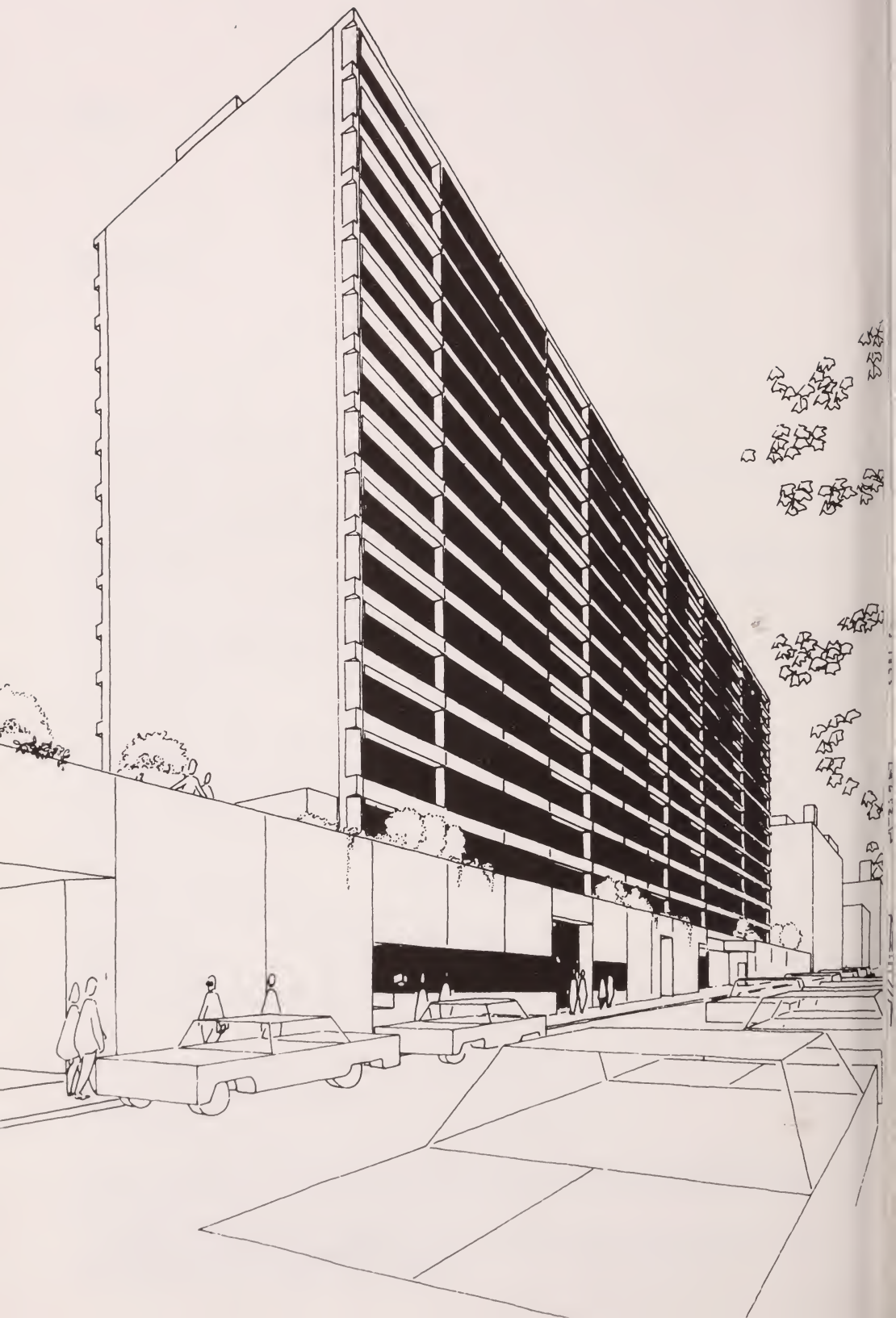

Graduate School of Medical Sciences

Purpose and History

The Graduate School of Medical Sciences, a semi-autonomous component of the Graduate School of Cornell University, provides an environment for advanced study and research in specific areas of the basic biomedical sciences. Graduate programs leading to the degree of Doctor of Philosophy are currently offered in the Fields of Biochemistry, Biological Structure and Cell Biology, Biology, Biomathematics, Biophysics, Biostatistics, Genetics, Microbiology, Neurobiology and Behavior, Pathology, Pharmacology, and Physiology. Certain of these graduate fields also offer programs leading to the degree of Master of Science. The faculty recommends the award of advanced general degrees not only as the result of the fulfillment of certain formal academic requirements, but also as evidence of the development and possession of a critical and creative ability in science. Proof of this ability is embodied in a dissertation which the candidate presents to the faculty as an original research contribution in the area of study.

Freedom and independence are key qualities of scholarship, and graduate education at Cornell attempts to preserve them for teacher and student. Each graduate student is supervised by his or her own Special Committee, a small group of faculty members selected by the student. Within the broad framework of requirements for residence, examinations, and thesis, and additional regulations of individual fields, the Cornell graduate student and this Special Committee are completely free to plan a program of study. The Graduate School of Medical Sciences sets no overall course, credit-hour, or grade requirements. The Special Committee has extraordinary independence in guiding the student's program, and a student will be recommended for a degree whenever this committee judges the student qualified.

The opportunity for graduate study leading to advanced general degrees in the biomedical sciences was first offered at the Cornell University Medical College in 1912 in cooperation with the Graduate School of Cornell University. In June of 1950, Cornell University, in association with the Sloan-Kettering Institute for Cancer Research, established a new division of the Medical College, the Sloan-Kettering Division, for the purpose of providing additional opportunities for graduate study in the biomedical sciences. The resultant expansion of the graduate faculty and facilities on the New York City campus prompted the organization in January 1952 of the Graduate School of Medical Sciences, which has full responsibility for advanced general degrees granted for study in residence at the New York City campus.

Facilities

The Medical College Division. The buildings of the Medical College extend along York Avenue from Sixty-eighth to Seventieth streets. They contain the main library, lecture rooms, and study laboratories for the basic science departments, and extensive research facilities for faculty and students.

The Sloan-Kettering Division. The facilities of the Sloan-Kettering Institute for Cancer Research consist of the Howard Laboratory and the Kettering Laboratory on East Sixty-eighth Street in New York City and the Walker Laboratory in Rye, New York. These provide lecture and seminar rooms and well-equipped laboratories for biomedical research.

Organization

Faculty

The Graduate School of Medical Sciences is composed of two relatively separate divisions: the Medical College Division, consisting primarily of the professional staff of the basic science departments of the Cornell University Medical College; and the Sloan-Kettering Division, consisting of the professional staff of the Sloan-Kettering Institute for Cancer Research. Within each of these divisions are fields or units of graduate instruction formed by faculty members with similar research and teaching interests. An individual faculty member may elect to affiliate with the one or two fields or units in which he or she agrees to sponsor graduate students.

Jacob S. Lasdon House, a student apartment residence.

General Committees

The General Committee of the Graduate School of Medical Sciences is an administrative board whose membership has responsibility for the academic affairs of the school. The committee considers matters referred to it by members of the faculty and offers recommendations to the faculty on questions involving the interests or policies of the Graduate School of Medical Sciences.

The General Committee is composed of the dean and the associate dean of the Graduate School of Medical Sciences, the associate director of the Sloan-Kettering Division, one elected representative from each of the fields of the Medical College Division and from each of the units of the Sloan-Kettering Division, and two student representatives elected by the graduate student body. The General Committee approves new fields, reviews the admission of students, approves students' major and minor fields, reviews the curriculum of each field, reviews the requirements for degrees, and acts on faculty and student petitions.

The chairperson of the General Committee is the dean, who is the academic administrative officer of the Graduate School of Medical Sciences and is also an associate dean of the Graduate School of Cornell University. The secretary of the General Committee is the associate dean, who is also an assistant dean of the Graduate School of Cornell University.

Admission

Applications

For admission to the Graduate School of Medical Sciences an applicant must (1) have a baccalaureate degree or the equivalent from a college or university of recognized standing, (2) have adequate preparation in the chosen field of study, and (3) show promise of ability to pursue advanced study and research, as judged by his or her previous record.

Inquiries about graduate study should be addressed to the Dean of the Graduate School of Medical Sciences, 1300 York Avenue, New York, New York 10021 or to the Associate Director of the Sloan-Kettering Division, 1275 York Avenue, New York, New York 10021.

Candidates may be admitted in September, February, or July, although places in the graduate program for February and July may not be available because of prior commitments to applicants for September admission. Applicants for February or July admission should correspond directly with the respective field representatives in the Medical College Division or the unit chairperson of the Sloan-Kettering Division regarding the availability of places.

Application material must be completed and returned to the Office of the Dean together with (1) official transcripts of records from all colleges and universities attended, (2) a statement of purpose of graduate study, and (3) two letters of recommendation from individuals in academic positions who know the applicant professionally. In addition, scores from the Graduate Record Examinations are usually required by individual fields to aid in their evaluation.

Applications for September or July admission and all credentials, including official transcripts of records from all colleges and universities attended, must be received by the deadline date of February 1.

Applications and credentials for February admission must be received by November 1.

Application fee. A nonrefundable charge of $10 is made for filing an application for admission.

The completed application and all supporting documents are reviewed by the Field (or Division) Credentials Committee. Applicants who are considered potentially acceptable are usually called for a personal interview. At the time of interview, after discussing his or her interests with the members of the field, the applicant may tentatively select a major sponsor. If accepted by the field, an application is returned to the dean who may refer it to the General Committee for final review and decision. A student is formally notified of acceptance for study in the Graduate School of Medical Sciences by a letter from the dean.

It is the policy of Cornell University actively to support equality of educational and employment opportunity. No person shall be denied admission to any educational program or activity or be denied employment on the basis of any legally prohibited discrimination involving, but not limited to, such factors as race, color, creed, religion, national or ethnic origin, sex, age, or handicap. The University is committed to the maintenance of affirmative action programs which will assure the continuation of such equality of opportunity.

Admission policies are also in conformity with the policy of New York State in regard to the American ideal of equality of opportunity as embodied in the Education Practices Act.

Categories

An applicant is accepted by the Graduate School of Medical Sciences (1) as a degree candidate for the M.S. or Ph.D., or (2) as a provisional candidate.

Provisional candidacy provides opportunity for a prospective degree candidate, whose educational preparation is difficult to evaluate, to begin graduate studies. On the basis of the record of accomplishment in the first half of the academic year, the adviser or temporary Special Committee of a provisional candidate may recommend to the dean that (1) provisional candidacy be changed to degree candidacy, (2) provisional candidacy be continued for the remainder of the academic year, or (3) provisional candidacy be terminated. A maximum of one academic year in the status of provisional candidacy is permitted and credit of a maximum of one residence unit may be allowed on petition, provided there is convincing evidence that performance has been of the same quality as that required of degree candidates.

Degree Requirements

Major and Minor Fields

A candidate for the degree of Master of Science is required to register for study in one major and one minor field. Each field decides whether the Special Committee of a candidate for the Ph.D. degree must have two or three fields represented. Accordingly, a candidate for the degree of Doctor of Philosophy is required to register for study in one major and one or two minor fields. At least one of the minors must be outside the area of the major field.

The Special Committee

The general degree requirements of the Graduate School of Medical Sciences are minimal in order to give maximum flexibility in choosing a desirable program of study. The student's program is determined with the aid and direction of a Special Committee, consisting of at least three faculty members chosen by the student from those fields that best fit his or her areas of interest. Satisfactory progress toward a degree is judged by the committee rather than by arbitrary standards imposed by the Graduate School of Medical Sciences. There are no regulations of the Faculty of the Graduate School of Medical Sciences governing the specific content of instruction, courses, or grades to which the Special Committee must subscribe, except those imposed by the fields. The committee is primarily responsible for the candidate's development as an independent scholar and scientist.

No later than four weeks after enrollment, a candidate must file a statement of the major and minor fields selected for study, after which the student must choose one faculty member to represent each field and to serve on a Special Committee. The faculty member representing the major field usually advises the student concerning the other selections and chairs the committee. At least one member of the committee must represent a field different from the candidate's major field. Members may agree to serve temporarily during the candidate's first year of residence until the candidate has had the opportunity to become acquainted with areas of research in the fields of his or her choice. On completion of this year of residence, a permanent Special Committee will be formed, the membership of which can be changed with agreement of all members of the old and newly formed committees and the approval of the dean. The members of the Special Committee decide on the student's program of study and research, and judge whether progress toward a degree is satisfactory. After consulting the other members, the chairperson of the Special Committee prepares term reports on the candidate for submission to the dean. The members of the committee serve on all the candidate's examining committees and they approve his or her thesis.

Registration and Course Grades

No student in the Graduate School of Medical Sciences may double-register for an advanced general or professional degree with any other school or college except the Cornell University Medical College.

At the beginning of each term, students are required to register with the Office of the Graduate School of Medical Sciences and to file a registration of courses form indicating all courses they will take. A fee of $10 is charged for late registration.

At the beginning of each course in which the student is enrolling, the student will complete a separate course registration form for the instructor. All courses for which the student registers for credit will be entered in the official record. Grades of graduate students are reported as: Excellent (E), Satisfactory (S), Unsatisfactory (U), Incomplete (I), Absent (Abs.), or Unofficially Withdrawn (W). A grade of Incomplete or Absent cannot be changed later than one term following the one in which the course was taken.

Registration for the summer is required of those graduate students who will be engaged in research

Residence

The faculty of the Graduate School of Medical Sciences regards study in residence as essential. Each candidate for an advanced general degree is expected to complete the residence requirements with reasonable continuity. A student must register each term from the time of his or her first registration in the Graduate School of Medical Science until the student either withdraws or completes a degree (unless a leave of absence has been granted). Full-time study for one-half academic year with satisfactory accomplishment constitutes one residence unit. Two units of residence are the minimal requirement for the master's degree and six units are the minimum for the doctoral degree. However, the time necessary to obtain the degree generally exceeds the minimal requirements. A candidate for the Ph.D. degree must spend two of the last four units of required residence in successive terms on the New York City or the Ithaca campus of Cornell University. No more than seven years may intervene between the time of first registration and the completion of all requirements for the doctoral degree. A student must complete all requirements for the master's degree in four years

Part-time graduate study, if it is necessitated by off-campus employment noncontributory to the major field of study, is not encouraged. Requests for part-time study must be reviewed by the General Committee. If permission is granted for part-time study, the student must be in residence at least half-time

The legislation with respect to eligibility of part-time students for residence units is as follows:

Employment	Residence Units Allowable Per Half Academic Year		
Total clock hours per week	*Contributory in major field; on campus*	*Noncontributory; on campus*	*Off campus*
0-10 hrs.	1 unit	1 unit	¾ unit
11-20 hrs.	1 unit	¾ unit	¾ unit
21-30 hrs.	¾ unit (teaching) ¾-1 unit (research)*	½ unit	———

* Time spent assisting in research, if it is contributory to the major field of study, shall be credited toward allowance of a full residence unit.

Transfer of Residence Credit

No residence credit will be granted for study outside the Graduate School of Medical Sciences to fulfill the requirements of the M.S. degree. No commitment can be made about granting residence credit toward the Ph.D. requirements for previous study in another graduate school until after the candidate has entered into residence at the Graduate School of Medical Sciences. At that time, the student's Special Committee may recommend acceptance of study outside the Graduate School of Medical Sciences to the General Committee, which will determine the number of residence units to be awarded. No credit can be transferred for study undertaken as an undergraduate or as a special student even in courses designed for graduate students.

A student who has satisfactorily completed two or more academic years of study toward the degree of M.D. at the Cornell University Medical College, or another accredited medical school in the United States with a curriculum equivalent to that of the Cornell University Medical College, may transfer a maximum of two units of residence credit after passing an evaluation examination administered by a committee appointed by the General Committee of the Graduate School of Medical Sciences.

Summer Research

Registration is required for the summer research period whether or not this effort will be credited toward residence unit accumulation. Students registered for summer research pay prorated tuition only if they are obtaining residence credit. However, no degree candidate is eligible for more than two residence units in any period of twelve consecutive months.

Study *In Absentia*

A candidate for the degree of Doctor of Philosophy may petition for permission to earn residence units for study away from Cornell University while regularly registered in the Graduate School of Medical Sciences. A candidate to whom this privilege has been granted may work temporarily under the immediate supervision of an individual designated by his or her Special Committee, but the candidate's program will continue to be directed by the committee. For study in absentia, not more than two residence units may be earned toward fulfillment of the minimal residence requirements for the Ph.D. degree. A student given leave for such study must register as a candidate in absentia and pay a fee of $75 per semester, and may continue his or her hospitalization insurance by payment of the annual premium directly to the Student Accounting Office of Cornell Medical College. If students in absentia take advantage of local privileges, such as the use of the library, desk space, Student Health Service, hospitalization insurance, and Cornell housing, the fee is $400 per semester.

Leave of Absence

A candidate who finds it necessary to interrupt the continuity of his or her residence must petition the dean for an official leave of absence. This written petition must specify the term of absence, state the reason for the requested leave of absence, and be approved by the student's Special Committee.

A student who will *not* be in residence but will return to the Graduate School of Medical Sciences to present and defend a thesis at the final examination, having completed all requirements for a degree except for the final examination, must petition for a leave of absence.

On return to the Graduate School of Medical Sciences for the final examination, the candidate will register as a Candidate for Degree Only and will pay a fee of $35.

Examinations

Three examinations are required by the Faculty of the Graduate School of Medical Sciences: (1) final examination for the M.S. degree, (2) examination for admission to doctoral candidacy, and (3) final examination for the Ph.D. degree. Examinations are administered by an Examining Committee consisting of a chairperson appointed by the dean, the members of the candidate's Special Committee, and, in the case of the Admission to Candidacy Examination, three additional members selected from the faculty of the Graduate School of Medical Sciences and/or of other institutions. In addition to these examinations, the candidate's major field may require a qualifying examination as part of its evaluation of the candidate after two units of residence have been completed.

For the M.S. degree: the final examination may be oral or both oral and written.

For the Ph.D. degree: the Admission to Candidacy Examination is both oral and written and certifies that the student is eligible to present a thesis to the Faculty of the Graduate School of Medical Sciences. The examination should be taken after course work is largely finished but before significant thesis research has begun. Accordingly, the usual examination time will be at the end of the second year of residence. The examination may not be taken until two units of residence credit have been accumulated, a minimum of

two units of residence credit is required after passing this examination before the final examination can be scheduled. The final examination for the Ph.D. degree is an oral defense of the candidate's thesis. It must be passed within four years after completion of the required residence units, or within seven years from the date of first registration, whichever is earlier.

Foreign Language Requirements

Each field of study has its own foreign language requirements. The student's Special Committee may require knowledge of foreign languages beyond the requirements of the fields listed in this *Announcement*.

Examinations in foreign languages will be administered by the Office of the Dean at the beginning of each term. As an alternative to this examination, the candidate may demonstrate proficiency by passing the reading part of the language qualification tests administered by the College Entrance Examination Board.

Theses

A principal requirement for both the M.S. and the Ph.D. degrees is the presentation of a thesis constituting an imaginative contribution to knowledge. Ordinarily, the thesis is written on a research topic in the candidate's major field of study, under the direction of the chairperson of his or her Special Committee. The faculty requires that the Ph.D. thesis be published in abstract and be recorded on microfilm.

Tuition and Fees

Tuition for a student regularly matriculated in the Graduate School of Medical Sciences is $5,500 for the academic year 1980–81 and is payable in two equal parts, the first of which is due at initial registration. Tuition includes fees for matriculation, hospitalization insurance, graduation, and miscellaneous thesis expenses.

For graduate students who (1) have been in continuous residence at Cornell in the same doctoral program and have passed their Admission to Candidacy Examination and (2) are not taking courses in the Medical College curriculum, a reduced charge of $800 per annum ($400 per semester) will be made for tuition and fees for the terms subsequent to the Admission to Candidacy Examination. For those students who will continue to take courses in the medical curriculum, an additional tuition charge, based on the Medical College tuition ($7,500 per annum), will be made for the medical course hours taken.

A graduate student registered for study in absentia pays a fee of $75 per semester. If students in absentia take advantage of local privileges, such as the use of the library, desk space, Student Health Service, hospitalization insurance, and Cornell housing, the fee is $400 per semester.

A graduate student who has previously fulfilled all other degree requirements, who has been granted a leave of absence, and who returns to the Graduate School of Medical Sciences to present a thesis and to take the final examination must register as a Candidate for Degree Only and pay a fee of $35.

A student who is to receive partial residence credit because of employment should apply for proration of tuition on forms obtainable at the Office of the Dean. Proration of tuition does not apply to the special reduced tuition of $400 per semester.

Any individual who owes money to the University will not be allowed to register or reregister in the University, receive a transcript of his or her record, have his or her academic credits certified, be granted a leave of absence, or have a degree conferred.

The amount, time, and manner of payment of tuition, fees, or other charges may be changed at any time without notice.

Refunds

Part of the amount personally paid for tuition will be refunded if the student obtains official certification of leave of absence or withdrawal from the Graduate School of Medical Sciences during the semester. Students who terminate their registration during a regular term in this manner will be charged tuition from the registration day to the effective date of the certificate as follows: first week, 10 percent; second week, 20 percent; third week, 30 percent; fourth week, 40 percent; fifth week, 60 percent; sixth week, 80 percent; seventh week, 100 percent. No charge will be made if the effective date of leave or withdrawal is within the first six days of the term, including registration day.

Financial Assistance

Financial assistance is available to qualified applicants. Individual fields or units may offer predoctoral research fellowships, research assistantships, or teaching assistantships. These positions may provide a stipend in addition to tuition. Information about these positions may be obtained directly from the field or unit at the time of application.

The fields in the Medical College Division also have available a limited number of tuition scholarships.

Nationwide, competitive, predoctoral fellowships are available from the National Science Foundation and the National Research Council. Information about these fellowships should be requested directly from the appropriate governmental agency.

New York State residents are eligible for several predoctoral fellowships and for the Tuition Assistance Program, which assists in tuition payments. Application forms may be obtained from the New York Higher Education Services Corporation, Student Financial Aid Section, Tower Building, Empire State Plaza, Albany, New York 12255.

Opportunity for part-time employment is often available in departmental research projects or other activities. Applications should be made directly to individual departments.

Several loan programs are available for the use of graduate students. Under these programs, repayment of the principal amount of the loan together with the interest on the loan can be deferred until after graduation.

The Frank Lappin Horsfall Jr. Award is endowed by funds provided in memory of Dr. Horsfall by his many friends and family. It is continued evidence of his concern for students manifest during his directorship of the Sloan-Kettering Division.

The award is available annually to a student of the Sloan-Kettering Division, who in the opinion of the Committee of the Faculty of the Sloan-Kettering Division, has been most distinguished, especially in the Admission to Doctoral Candidacy Examination.

Student Health Services

Graduate students are provided with hospitalization and major medical insurance through the Cornell University Medical College Student Health Plan, for which the Medical College is self-insured. The cost of services rendered to students is borne directly by the Medical College. The self-insurance program is a secondary plan and use of other insurance through the student's family is required first. Insurance may be purchased for student's eligible dependents who do not have other health insurance available to them.

Complete ambulatory medical care is provided at no charge for all students enrolled in the Graduate School of Medical Sciences through the Personnel Health Service of the Medical Center. Referrals will be made to the New York Hospital clinics and private physicians when appropriate. Students will be issued New York Hospital clinic cards and will receive courtesy privileges in the New York Hospital Pharmacy.

The student matriculating for the first time is required to have a physical examination by a member of the Health Service staff. In addition, the student must report for a chest X-ray examination, tuberculin test, and necessary immunizations. Office hours are held daily from 1-2 p.m. by the Health Service staff.

Spouses and families of students are not eligible for care through the Personnel Health Service but will be referred to appropriate members of the New York Hospital staff for medical treatment.

A student on leave for study in absentia may continue hospitalization insurance by payment of the annual fees directly to the Student Accounting Office, Room C-015 Medical College Building.

A student on a leave of absence for reasons other than study in absentia is not eligible to receive student health benefits.

Residence Halls

F. W. Olin Hall, a student residence, is at 445 East Sixty-ninth Street directly across from the Medical College entrance on York Avenue. Olin Hall contains a gymnasium, snack bar, lounges, and 278 residence rooms. Each residence room is furnished as a single bedroom-study, but since two rooms share a connecting bath, they may be used as a suite for two students. The rooms are completely furnished. The occupancy charge for a student is $126 a month.

Livingston Farrand Apartments, also located on East Sixty-ninth Street just beyond Olin Hall, have furnished apartments of 1½, 2, 3, and 4 rooms. Cooking facilities are provided in these apartments and occupancy charges range from $155 to $304 each month.

Jacob S. Lasdon House, an apartment residence, is located at 420 East Seventieth Street. This building contains studio, one-bedroom, and two-bedroom apartments. Apartments are fully furnished and monthly occupancy charges range from $283 to $477 including utilities.

The fees listed above may be changed at any time without previous notice.

Cornell University

Fields of Instruction

Instruction at the Medical College Division

Biochemistry

Faculty

A. L. Boskey, E. Breslow, A. J. L. Cooper, J. Cornell, T. Duffy, G. F. Fairclough, J. D. Gass, H. Gilder, J. Goldstein, O. W. Griffith, R. H. Haschemeyer, B. Horecker, A. Meister, A. Novogrodsky, A. S. Posner, S. G. Powers, J. R. Rachele, R. R. Riggio, A. L. Rubin, B. Saxena, E. T. Schubert, R. L. Soffer, K. H. Stenzel, S. S. Tate, P. P. Trotta, D. Wellner, K. Woods

Field Representative

S. S. Tate, Department of Biochemistry, Room E-106, Medical College

Graduate instruction is offered leading to the Ph.D. or M.S. degrees. Within the framework of degree requirements and in consultation with the student, the course of study is planned to fit the needs of the individual. Athough formal course work is required, emphasis is placed on research. Research opportunities exist in various fields of biochemistry including enzymology, structure and function of proteins and nucleic acids, molecular biology, physical biochemistry, and the intermediary metabolism of amino acids, carbohydrates, nucleic acids, and lipids. Entering graduate students usually work for short periods in several of the laboratories of the faculty members of the field before beginning their thesis research. Students are encouraged to choose challenging and fundamental research problems that are on the frontiers of biochemistry.

The laboratories of the faculty members are equipped with virtually all of the instruments and facilities required for modern biochemical research; thus, graduate students are instructed in such methodology as chromatography, countercurrent distribution, radioactive and stable isotope techniques, spectrophotometry, electrophoresis, and analytical ultracentrifugation.

Students who undertake graduate study in biochemistry must have a sufficiently comprehensive background in chemistry to pursue the proposed course of study and must present evidence of knowledge of biology, general experimental physics, and mathematics (including differential and integral calculus). Students may remedy deficiencies in these areas during the first year of graduate study. The Graduate Record Examinations (the Aptitude Test and the Advanced Test in chemistry) are ordinarily required.

The language requirement for the Ph.D. and the M.S. degrees is proficiency in one modern foreign language acceptable to the student's Special Committee. Proficiency in a computer programming language, as demonstrated by executing a meaningful program, may substitute for proficiency in a foreign language.

Students are encouraged to complete applications for fall admission before the preceding February 1.

Special Interests of the Faculty

A. L. Boskey: mechanisms of biological calcification; role of phospholipid in bone and tooth formation, structural studies of hard tissue by X-ray crystallography and electron microscopy

E. M. G. Breslow: structure-function relationships in the interactions between posterior pituitary proteins and hormones; protein-protein and metal ion-protein interactions

A. J. L. Cooper: ammonia, amino acid and α-keto acid metabolism in the brain; use of ^{13}N isotopic tracers in brain metabolic studies

J. S. Cornell: biochemistry of reproduction; protein chemistry of the placenta; endocrine influences in gestational diabetes and toxemia of pregnancy; anterior pituitary hormones

T. E. Duffy: neurochemistry; carbohydrate and energy metabolism in altered functional states of brain, ammonia detoxification and hepatic coma; biochemistry of developing brain

G. F. Fairclough: clinical biochemistry; pulmonary surfactant biosynthesis; lipoprotein structure and function
J. D. Gass: mechanism of enzyme action; application of computers to biological problems
H. Gilder: pulmonary lamellar bodies and surfactant, lung lipid synthesis, evaluation of surfactant in etiology of oxygen toxicity, metabolic response to surgery, experimental shock
J. Goldstein: structure-function of red cell surface antigens; cell surface and differentiation; protein synthesis
O. W. Griffith: design and synthesis of enzyme specific substrates and inhibitors; *in vivo* manipulation of metabolic pathways; enzyme mechanisms; sulfur amino acid metabolism
R. H. Haschemeyer: structure of fibrinogen; subunit interactions in proteins; electron microscopy of macromolecules; lipoprotein and membrane structure; computer simulation and numerical analysis
B. L. Horecker: intermediary metabolism; structure-function relationships in biomolecules
A. Meister: enzymology; amino acid metabolism and its relationships to human disease
A. Novogrodsky: lymphocyte activation and cell-cell interactions; cellular and transplantation immunology
A. S. Posner: crystal chemistry; ultrastructural biochemistry; atomic structure of bone; hard-tissue chemistry
S. G. Powers: regulation of enzyme activity; protein-protein interactions; mechanism of enzyme action
R. R. Riggio: transplantation; dialysis; biochemistry of immunological phenomena associated with allografts, gestation, and malignancy
A. L. Rubin: collagen structure and function; biomaterials research; dialysis; transplantation research
B. Saxena: chemistry, measurement, and mechanism of action of pituitary protein hormones
E. T. Schubert: enzyme studies of the developing kidney, clinical biochemistry
R. L. Soffer: angiotensin-converting enzyme; amino-acyl-tRNA-protein transferases; studies of membrane-bound enzymes
K. H. Stenzel: transplantation; lymphocyte activation
S. S. Tate: amino acid and peptide transport; plasma membrane enzymes; metabolism and physiology of hypothalamic releasing hormones
P. P. Trotta: molecular basis of the immunodeficiency diseases; biochemistry of colon cancer; structure-function relations in adenosine deaminase
D. Wellner: mechanisms of enzyme action; enzyme kinetics; protein structure
K. R. Woods: physical-chemical understanding of human blood fractions, blood coagulation; structure of antibodies

Courses

1. Biochemistry Offered jointly by the faculties of the Medical College and Sloan-Kettering Divisions. Details are given on p. 28 under Interdivisional Courses

2. Introduction to Research Experimental biochemistry dealing with the isolation, synthesis, and analysis of substances of biochemical importance (enzymes, coenzymes, various metabolites, and intermediates), and study of their properties by various chemical and physical techniques. The student obtains this varied research experience by spending approximately two months in the laboratory of each of four faculty members of his or her choice. For incoming graduate students majoring in biochemistry. The staff.

3. Selected Topics in Biochemistry Advanced study in selected topics is offered in areas such as (1) nucleic acids and protein synthesis; (2) intermediary metabolism; (3) kinetics and enzyme mechanism; (4) protein chemistry; (5) structure of membranes and the biochemistry of transport; and (6) hormones. Generally, one or two of these courses is offered yearly in the third trimester. The staff.

4. Advanced Biochemistry Offered jointly by the faculties of the Medical College and Sloan-Kettering Divisions. Details are given on p. 28 under Interdivisional Courses.

5. Physical Methods Offered jointly by the faculties of the Medical College and Sloan-Kettering Divisions. Details are given on p. 28 under Interdivisional Courses.

Biological Structure and Cell Biology

Faculty

R. Bachvarova, C. G. Becker, J. M. Bedford, D. Bennett, D. C. Brooks, G. Dooher, F. G. Girgis, J. Goldstein, R. L. Greif, W. D. Hagamen, M. D. Hamburg, B. B. Kaplan, T. H. Meikle, Jr., C. R. Minick, R. Nachman, T. C. Rodman, C. A. Santos-Buch, B. Saxena, E. T. Schubert, J. L. Sirlin, G. W. Siskind, D. Soifer, M. Spiegelman, K. H. Stenzel, D. H. Sussdorf, R. C. Swan, S. S. Wachtel, J. C. Weber, J. M. S. Winterkorn

Field Representative

J. L. Sirlin, Department of Anatomy, Room A-229, Medical College

Graduate study in the Field of Biological Structure and Cell Biology leads to a Ph.D. degree and emphasizes the basic relationships between structure and function of biological systems at all levels of organization. Thus the field is fundamentally concerned with the nature, development, and functional modulation of biological systems, as well as significance of configuration, pattern, and other spatial relations in biological systems. The scope of interest extends from the molecular level to that of the whole organism and embraces normal as well as pathological structure.

Opportunities for research training include the investigation of cellular fine structure using such techniques as light and electron microscopy, isolation and analysis of cellular subfractions by differential ultracentrifugation, cytochemistry, molecular biochemistry, and enzymology.

For graduate study in the field, adequate undergraduate preparation in biology, chemistry (including

organic chemistry), physics, and mathematics is recommended. Requirements for admission are flexible in proportion to the promise and accomplishments of the applicant. Applicants are requested to present the results of the Graduate Record Examinations.

Requirements for minor sponsorship in the field will be arranged with individual students, but research experience in the minor sponsor's laboratory is strongly encouraged.

In addition to the courses listed below, appropriate courses for graduate students in the field are Biochemistry, Physiology, and those courses given by the Field of Neurobiology and Behavior.

A reading knowledge of a foreign language is desirable.

The field requires a qualifying examination at the end of the first year of residence. At the discretion of the examining committee, the examination may be written, or oral, or both. The Admission to Candidacy Examination required by the Graduate School of Medical Sciences must be taken before six units of residence credit have been accumulated and before substantial progress has been made in the candidate's thesis research.

Special Interests of the Faculty

R. Bachvarova: molecular developmental biology
C. G. Becker: cardiovascular and renal disease; immunopathology
J. M. Bedford: physiology of mammalian gametes and reproductive tract
D. Bennett: mammalian genetics, with special reference to genetic regulation during early embryonic development
D. C. Brooks: spontaneous electrical activity of the central nervous system; brain stem influences upon the visual system during sleep and wakefulness in the cat
G. Dooher: genetics and fine structure of male reproduction
F. G. Girgis: the cranial and facial sutures, their development, structure, and the analysis of sutural position; of particular interest are factors inducing chondrogenesis in the cranial vault
J. Goldstein: role of RNA in protein synthesis, fractionation of nucleic acids; role of macromolecules and protein synthesis in the maturation of red blood cells
R. L. Greif: physiology of the thyroid gland and its secretion
W. D. Hagamen: self-stimulation, habituation, and changes in affective behavior in cats; artificial intelligence in computers
M. Hamburg: neurochemistry and regulatory mechanisms of the enzymes involved in monoamine biosynthesis
B. B. Kaplan: gene activity and its regulation in brain
T. H. Meikle, Jr.: animal studies of neural mechanisms basic to learned behaviors, particularly visual learning
C. R. Minick: pathogenesis of arteriosclerosis and hypertension; immunopathology; electron microscopy
R. L. Nachman: biology of platelets
T. C. Rodman: analytical cytology of cell nuclei, cytogenetics
C. A. Santos-Buch: cellular biology: immunopathology cardiovascular disease; electron miscroscopy
B. Saxena: chemistry, measurement, and mechanism of action of pituitary protein hormones
E. T. Schubert: enzyme studies of the developing kidney; investigation of renal dysfunction at enzyme level
J. L. Sirlin: molecular biology and pharmacology of brain function
G. W. Siskind: immunology; ontogeny of immune response; antibody heterogeneity
D. Soifer: structure and function of microtubules
M. Spiegelman: early embryonic development, particularly with respect to cell movement and cellular interactions
K. Stenzel: transplantation; dialysis and biomaterials research
D. H. Sussdorf: cellular interactions during the immune response; function of the thymus and related lymphoid tissues in development of immunocompetence
R. C. Swan: fine structure of excitable cells
J. C. Weber: vitamin D and mineral metabolism in hard tissue
S. S. Wachtel: immunogenetics
J. M. S. Winterkorn: visual behavior and learning after brain lesions

Courses

1. Microscopic Anatomy This course is offered jointly by the Field of Biological Structure and Cell Biology of the Medical College Division and by the Biology Unit of the Sloan-Kettering Division. Details are given on p. 29 under Interdivisional Courses.

2. Gross Anatomy Regional anatomy is studied principally through dissection of the human body. Supplementing this technique are prosections by instructors, tutorial group discussions, and radiographic and endoscopic demonstrations. Enrollment is limited and students should consult the staff early in order to determine the availability of places. First and second trimesters. The staff.

Biomathematics

Faculty

S. I. Rubinow

Field Representative

S. I. Rubinow, Division of Biomathematics, Room KB 122, Kips Bay Building, Medical College

The Field of Biomathematics offers a wide range of opportunities for the development of quantitative methods in the biological and medical sciences, with special emphasis on the application of mathematics Graduate study programs leading to advanced degrees in the Field of Biomathematics are available to students whose primary interests are mathematical, but who want to concentrate on biological or medical applications.

Graduate students are admitted to study in this field from a variety of educational backgrounds, including the several branches of engineering and the physical and biological sciences, as well as mathematics. Their programs of study include a thorough grounding in mathematical methods and a particular biological area of interest.

Applicants are expected to support their applications with their scores on the Graduate Record Examinations in both the Aptitude and the Advanced Tests.

The thesis in biomathematics must be a mathematical contribution toward the solution of a problem arising in a biomedical area.

Graduate students in the Field of Biomathematics are required to obtain thorough training in linear algebra, complex variables, partial differential equations, and boundary value problems. In addition to other courses, an appropriate plan of study in the relevant aspects of biology, chemistry, physics, and medicine will be made to suit the particular area of application of the individual student. A programming language such as FORTRAN is required in lieu of a foreign language.

Special Interests of the Faculty

S. I. Rubinow: cell kinetics; enzymatic reactions; physiological systems; reaction-diffusion phenomena; blood flow

Courses

1. Introductory Biomathematics I, II, and III Introduction to the use of elementary mathematics in various areas of medicine and biology. The course is divided into three parts, offered separately in each trimester. Topics treated mathematically include the simplest rate processes in biology, cell growth, theory of enzyme kinetics, compartment equations, and transport processes, especially convection, diffusion, and sedimentation. Two hours each week; hours to be arranged. Prerequisite: elementary calculus. Unlimited enrollment. S. I. Rubinow

2. Biomathematics Seminar Presentation of research investigations by the staff and student reports on various topics chosen from current literature. Required of biomathematics majors. One hour each week; hours to be arranged. The staff.

Genetics

Faculty

F. H. Allen, V. G. Allfrey, K. Artzt (SKD*), R. Bachvarova, D. Bennett (SKD), J. L. Biedler (SKD), E. A. Boyse (SKD), R. S. K. Chaganti (SKD), B. S. Danes, G. Darlington, G. A. Dooher (SKD), B. Dupont (SKD), J. L. German III, M. Hoffmann (SKD), E. Johnson, R. M. Krug (SKD), G. Litman (SKD), S. D. Litwin, P. W. Melera (SKD), L. J. Old (SKD), T. C. Rodman, P. Rubinstein, S. Silagi, L. M. Silver, M. Siniscalco (SKD), J. L. Sirlin, M. Spiegelman (SKD), J. Stavnezer (SKD), G. Vidali, R. J. Winchester

* Sloan-Kettering Division

Field Representative

G. Darlington, Department of Medicine, Room F-208, Medical College

Academic and reseach training is available chiefly in the following areas: cytogenetics, developmental genetics, genetics and cell differentiation, human biochemical genetics, human somatic cell genetics, immunogenetics, microbial genetics, and nucleic acid biochemistry. The faculty includes members of the preclinical and clinical departments of the Medical College and faculty members of the Sloan-Kettering Division. A unique opportunity for integrating the study of genetics with other biological and medical interests is thus provided. Within broad limits, students pursue their own programs according to particular interests.

The usual prerequisites for admission to graduate study for an advanced degree in genetics are undergraduate work in chemistry or biology, and courses in general genetics, general chemistry, organic chemistry, general biology, general physics, and mathematics through calculus. Applicants are required to present Graduate Record Examinations scores in the Aptitude Tests and in the Advanced Test in chemistry or biology.

Courses generally required of genetics majors are those numbered 1 through 6 below, and Graduate Biochemistry and Microscopic Anatomy, given by the Field of Biochemistry and by the Biology Unit of the Sloan-Kettering Division, respectively. Other courses for students in genetics include those numbered 7 through 9 and Advanced Virology offered by the Field of Microbiology.

Students minoring in genetics are required to take two semesters of the Genetics Seminar and one additional course from the following: Advanced Genetics, Advanced Microbial Genetics. A limited period of work in the laboratory of the minor sponsor is recommended.

Requirements for foreign language are at the discretion of the student's Special Committee, although the field recommends a reading knowledge of French or German.

An oral qualifying examination is required at the end of the first year of residence and the Admission to Candidacy Examination must be taken at the end of the second year of graduate work. The oral portion of the Admission to Candidacy Examination will include discussion of the specific research proposal and general biological topics.

Special Interests of the Faculty

F. H. Allen: immunogenetics of blood groups
V. G. Allfrey: cell nucleus chemistry, chromosomal proteins; genetic control
K. Artzt: genetics of embryonal tumors
R. Bachvarova: developmental molecular biology
D. Bennett: mammalian developmental genetics; immunogenetics
J. L. Biedler: cytogenetics
E. A. Boyse: mammalian immunogenetics
R. Chaganti: human genetics; cell genetics
B. S. Danes: somatic cell genetics (with particular emphasis on human genetic metabolic errors)

G. Darlington: human genetics; cell genetics
G. Dooher: genetics and fine structure of male reproduction
B. Dupont: human immunogenetics
J. L. German: mammalian cell genetics and cytogenetics
M. Hoffmann: H-2 immunogenetics
E. Johnson: eukaryotic gene expression and packaging
R. M. Krug: viral and molecular genetics
G. Litman: immunogenetics
S. D. Litwin: genetics of immunoglobulins and serum proteins
P. W. Melera: molecular eukaryotic genetics
L. J. Old: tumor immunovirology
T. C. Rodman: cytogenetics with emphasis on mechanisms of genetic control
P. Rubenstein: immunogenetics; histocompatibility; genetics; immunology; immunohematology
S. Silagi: gene action and cellular differentiation in culture
L. M. Silver: molecular biology of development and embryogenesis
M. Siniscalco: somatic cell genetics
J. Sirlin: molecular biology of brain function
M. Spiegelman: early embryonic development
J. Stavnezer: isolation and differentiation of immunoglobulin genes
G. Vidali: chromosomal proteins; molecular genetics
R. J. Winchester: human genetics

Courses

1. Genetics Seminar The topics for 1980-81 are Population and Somatic Cell Genetics and Human Genetics. Sponsors will be M. Siniscalco and S. D. Litwin.

2. Medical Genetics Conference Consists of a series of conferences on topics in medical genetics. Offered every two weeks throughout the year. M 4. S. D. Litwin.

3. Genetics Journal Club An informal meeting of students and staff at which current literature or research is discussed. Held every two weeks throughout the year. F 12. R. Bachvarova.

4. Advanced Genetics Designed to give the student a sound background in genetic theory; an in-depth consideration of the gene as a unit of heredity. First semester: three hours each week to be arranged. Not offered 1980-81. D. Bennett.

5. Introduction to Research in Genetics Students are expected during their first year to spend time and perform experiments in the laboratories of three faculty members of the Field of Genetics.

6. Medical Genetics Rounds Students participate in the activities of the Medical Genetics Clinic by assisting in the taking of family histories, construction of pedigrees, and in genetic counseling. Ward rounds are carried out weekly. The staff of the Division of Human Genetics.

7. Karyotyping Practical experience in chromosome analysis in the laboratory. Introduction to tissue culture techniques. Limited to two students. Third trimester: one day a week for seven weeks, hours to be arranged. J. L. German.

8. Somatic Cell Genetics The course will include lectures and discussions of a variety of topics including studies of mutagenesis, culture techniques, cell hybridization and gene mapping, gene expression, metabolic cooperation, and inborn errors. Drs. Danes, Darlington, German, Silagi, and Siniscalco.

9. Immunogenetics An advanced elective in immunogenetics will be offered alternate years. The program will consist of twelve weekly meetings of two to three hours each in which a general description of an area of immunogenetics is followed by reports on selected papers and by discussion. General concepts in immunogenetics are covered, certain of the more widely used laboratory approaches are critically discussed, and the biological problems associated with the histocompatibility gene complex and genetic control of immunoglobulins is emphasized. S. Litwin and P. Rubenstein.

Microbiology

Faculty

R. W. Dickerman, L. Korngold, W. M. O'Leary, R. B. Roberts, C. A. Santos-Buch, W. F. Scherer, L. B. Senterfit, G. W. Siskind, D. H. Sussdorf, M. E. Weksler, M. E. Wiebe

Field Representative

R. W. Dickerman, Department of Microbiology, Room B-414, Medical College

The Field of Microbiology offers graduate training leading to the Ph.D. degree. Under special circumstances, candidacy towards the M.S. degree will be considered. Candidates may select an area of research from such microbiological topics as general and medical bacteriology, microbial chemistry and physiology, microbial genetics, immunology, and virology.

Prospective students should complete at the undergraduate level a minimum of one year (or its equivalent) in general chemistry, organic chemistry, general physics, mathematics (including college algebra), botany or zoology (preferably both), and one semester or its equivalent of analytical or quantitative chemistry. General microbiology or bacteriology and calculus are strongly recommended. Students who have not completed the above requirements may be admitted to graduate study on the condition that deficiencies be corrected soon after admission. Applicants are ordinarily required to present Graduate Record Examinations scores for the Aptitude Tests and for the Advanced Test in chemistry or biology.

Individual programs are determined by the student's Special Committee, composed of faculty members representing the major and minor fields. Students majoring in microbiology select their primary courses from those listed below. The nature and number of

other courses that may be taken at this institution or at nearby universities will depend on the students' minor fields, their research activities, their individual interests, and the advice of the Special Committees. All students majoring in microbiology are required to assist in the teaching of courses offered by the field.

Students majoring in other fields who elect to minor in microbiology are ordinarily required to take the course Microbiology and an Introduction to Infectious Disease. In addition, students are required to enroll in an advanced course in microbiology or participate in a research project in the laboratory of their minor sponsors. In general this research is expected to take one to three months to complete, depending upon whether the project is pursued on a full-time or part-time basis.

Ph.D. candidates are required to be proficient in one modern foreign language acceptable to their Special Committees.

Although a qualifying examination is not ordinarily given, a student's Special Committee has the prerogative of requiring it. The Admission to Candidacy Examination is administered by a committee consisting of a chairperson appointed by the dean, the student's Special Committee, and three additional faculty members in the Field of Microbiology. The written portion of this examination tests for basic facts and concepts in the candidate's area of study and for the candidate's problem-solving ability within and across disciplinary boundaries. The oral examination provides an opportunity for the student to correct deficiencies in the written examination, to be examined further on general knowledge, and to discuss and be questioned on his or her planned or current research.

Special Interests of the Faculty

R. W. Dickerman: involvement of birds and mammals in the ecology of viruses pathogenic to man
L. Korngold: antigenic structure of immunoglobulins and of various human tissues
W. M. O'Leary: microbial cellular composition; mechanisms of pathogenesis; microbial lipids; antibiotic function, instrumental characterization of bacteria; anaerobiasis
R. B. Roberts: interactions between microorganisms and phagocytic cells
C. A. Santos-Buch: cellular biology; immunopathology; cardiovascular disease; electron microscopy
W. F. Scherer: cell-virus relationships; virus virulence; host defense mechanisms; ecology and epidemiology of arbo viruses, especially mosquito-borne encephalitis viruses of tropical North and South America
L. B. Senterfit: antigenic structure of mycoplasma; pathogenesis of respiratory viral and mycoplasmic disease; vaccine development, clinical microbiology
G. W. Siskind: factors involved in control of the immune response, especially anti-idiotype antibody; control of antibody affinity and heterogeneity; ontology of heterogeneity of antibody affinity; effect of aging on the immune response
D. H. Sussdorf: immunological factors in carcinogenesis; immunocompetence of the athymic ('nude') mouse; macrophage function
M. E. Weksler: lymphocyte interactions with autologous cells in autoimmune and neoplastic diseases; immunobiology of aging
M. E. Wiebe: molecular virology; mechanisms of virus replication, host cell response, viral interference, and viral virulence

Courses

Students who want to attend any of the following courses either for credit or as auditors should contact the field representative or the faculty member responsible for each course well in advance of the beginning of each course. In general, as many students as possible are accommodated in lectures; however, participation in laboratory sections is restricted.

1. Microbiology for Graduate Students (Interdivisional.) Not offered 1980-81.

2. Microbiology and an Introduction to Infectious Disease Presented in the first and second trimesters. Consists of laboratory experiments, lectures, and group discussions. The laboratory work includes an introduction to the procedures used in studying microorganisms, experiments on various physical and biological manifestations of antigen-antibody reactions, the actions of chemotherapeutic agents, a survey of the microbial flora of the upper respiratory and lower intestinal tracts of healthy humans, and an intensive study of the causal agents of specific infections, including fungi, spirochetes, rickettsiae, and viruses, as well as bacteria. The lectures are directed toward the development of basic concepts, particularly the principles involved in microbial growth, the principles underlying active immunization, and the factors that enter into host-parasite relationships. Emphasis is placed on aspects related to the etiology, pathogenesis, epidemiology, and prevention of infectious disease. Special attention is also given to the immunological principles underlying such noninfectious conditions as hypersensitivity, autoimmunity, and graft rejection. Offered every year. Microbiology staff and invited lecturers.

3. Advanced Diagnostic Microbiology The lecture and laboratory sessions acquaint the student with the procedures used in and techniques of management of a clinical microbiology laboratory. Emphasis is upon developing the student's capability in the isolation and rapid identification of organisms from various types of clinical specimens. Liberal use is made of clinical materials available through the diagnostic laboratories of the New York Hospital. Offered every year in the third trimester. Hours by arrangement. L. B. Senterfit

4. Microbial Chemistry and Physiology Lectures cover literature and methodology pertinent to physicochemical properties of microorganisms and their environments, the growth and death of microorganisms, chemical composition of cells and subcellular structures, nutritional requirements, microbiological assay and auxotrophic mutants, energy metabolism, degradations and biosyntheses, the physiology of pathogenesis, and important microbial products. Laboratory sessions provide experience with large-

scale culture and recovery of cells, synthetic media, microbiological assay, extraction of cellular constituents, respirometry, and studies of substrate utilization employing radioactive metabolites. Minimal prerequisites: general microbiology, qualitative and quantitative analysis, organic chemistry, and at least one semester (or its equivalent) of biochemistry. Offered every other year in the third trimester. Offered 1980-81. W. M. O'Leary.

5. Advanced Microbial Genetics. Selected concepts of molecular genetics are examined using both prokaryotic and eukaryotic microorganisms as models. Topics include intra- and intercistronic complementation, mitotic and meiotic recombination, genetic control mechanisms, gene conversion, polyploidy and aneuploidy, genetic interference, mechanisms of suppression, and polarity. The course is designed to elucidate the genetic methods available for studying hereditary material. Offered every second year in the third trimester, one lecture weekly. Not offered 1980-81.

6. Advanced Immunology. Offered jointly by the faculties of the Medical College and Sloan-Kettering Divisions. Details are given on p. 28 under Interdivisional Courses.

7. Advanced Virology. Presents, in lectures and laboratory sessions, modern concepts and techniques of virology. Virus structure, chemical composition, physical and biologic properties, and relationships with host cells are considered in depth. Minimal prerequisites for credit are general microbiology and at least one semester (or its equivalent) of biochemistry. M. E. Wiebe and W. F. Scherer.

8. Research on Special Problems. For students who want significant experience in specialized procedures, which they could not obtain otherwise, the field offers individualized research on special problems. The nature, complexity, and time required for such research vary according to the needs and desires of each student. Such experience is available in each specialty covered by the faculty of the field and can be arranged by consultation of the student with the appropriate faculty member. Available each year and throughout the year. The staff.

9. Thesis Research in Microbiology. Required of all students taking a major in microbiology. Offered yearly and throughout the year. The staff.

10. Microbiology Seminar. Reports on surveys of the literature in the field and on current research. Presented by graduate students, faculty, and visiting scientists. Attendance is required of all students majoring or minoring in microbiology throughout their programs of study. Offered yearly and throughout the year. One-hour sessions alternate weeks, hours to be arranged. W. M. O'Leary.

11. Clinical Microbiology Program—Ithaca and New York Campuses. During the senior year of a special undergraduate study program at Ithaca or during the year after receiving a bachelor's degree, the student may concentrate on developing skills in clinical microbiology at the Cornell Medical School-New York Hospital in New York City. Students participate in courses concerned with microbiology, an introduction to infectious diseases, diagnostic microbiology, parasitology, immunology, and virology, in addition to working in the hospital diagnostic laboratory. This clinical microbiology specialization is designed to prepare students for employment in clinical microbiology laboratories. However, it could also be selected by students interested in further education or other careers.

Neurobiology and Behavior

Faculty

I. B. Black, D. C. Brooks, A. J. L. Cooper, T. Duffy, D. Gardner, M. S. Gazzaniga, J. G. Gibbs, Jr., G. E. Gibson, B. Grafstein, W. D. Hagamen, M. Hamburg, K. A. Halmi, T. H. Joh, B. B. Kaplan, J. A. Kessler, K. W. Lieberman, I. G. McQuarrie, T. H. Meikle, Jr., M. Okamoto, V. M. Pickel, F. Plum, D. J. Reis, W. F. Riker, Jr., W. N. Schoenfeld, J. A. Sechzer, C. P. Smith, P. E. Stokes, J. M. S. Winterkorn.

Field Representative

B. B. Kaplan, Department of Anatomy, Room A-016, Medical College.

The Field of Neurobiology and Behavior provides training in the study of the nervous system. It includes the disciplines of neuroanatomy, neuroembryology, neurophysiology, neuropharmacology, neurochemistry, neuroendocrinology, and neuropsychology and perception. The program of the field emphasizes a multidisciplinary approach to the study of the nervous system, based on the belief that future advances in our understanding of the nervous system will be derived from knowledge of the thinking and research techniques employed by more than one discipline. Toward this end, the program of the students entering the field is planned in consultation with several staff members, and the students are expected to spend some period of time working closely with members of the faculty whose interests are related to theirs. In addition, there are regularly scheduled seminars in the field during which various aspects of work in progress are presented and discussed. By these means, the students are afforded the broadest possible view of the field during their total training experience.

The student who chooses Neurobiology and Behavior as a major field will be required to satisfy the requirements of the courses in neuroscience, statistics, and biomathematics, and two of the following: microscopic anatomy, physiology, biochemistry, or pharmacology. The student whose major field is Neurobiology and Behavior must have two minors, at least one of which is outside the field. In addition, participation in the seminar program is expected. While there are no language requirements, it is suggested that the student achieve mastery of a modern foreign language or a computer programming language. When neurobiology is chosen as a minor field of study, the student is required to participate in the neuroscience course and

the seminar program as well as obtain any additional experience that the minor sponsor may suggest.

Applicants to the Field of Neurobiology and Behavior are expected to have had adequate undergraduate training in biology, organic chemistry, physics, and mathematics. Graduate Record Examination scores are to be submitted with the application. An interview with the applicant is considered highly desirable.

Special Interests of the Faculty

I. Black: developmental neurobiology in periphery and brain, including enzyme regulation, transsynaptic controls; genetic influences
D. Brooks: brain stem influence on the electrical activity of the visual system during sleep and wakefulness
A. J. L. Cooper: ammonia, amino acid and α-keto acid metabolism in the brain; use of ^{13}N isotopic tracers in brain metabolic studies
T. Duffy: carbohydrate and energy metabolism in altered functional states of the brain; ammonia detoxification and hepatic coma; effect of anoxia on the developing brain
D. Gardner: neurobiology and biophysics of invertebrate synaptic transmission
M. S. Gazzaniga: neuropsychological approaches to behavior
J. Gibbs: central and peripheral mechanisms of feeding behavior in animals and humans
G. E. Gibson: relationship of carbohydrate metabolism to neurotransmitter synthesis
K. A. Halmi: endocrine investigations; epidemiological-demographic treatment studies of eating disorders
M. Hamburg: regulatory mechanisms for the biosynthesis of catecholamine neurotransmitters
T. H. Joh: neurochemistry and regulatory mechanisms of the enzymes involved in monoamine biosynthesis
B. B. Kaplan: gene activity and its regulation in brain
J. A. Kessler: biochemistry of peptidergic neurons and physiology of nerve growth factors
K. W. Lieberman: neurochemical aspects of mental illness and alcoholism
T. Meikle: animal studies of neural mechanisms basic to learned behavior, particularly visual learning
I. G. McQuarrie: regeneration in the optic system
M. Okamoto: neuropharmacology; sedative-hypnotic drug dependence
V. M. Pickel: immunocytochemistry of monoamine synthesizing enzymes in development and regeneration
F. Plum: cerebral metabolism in disease states; central regulation systems
D. J. Reis: central neural regulation of cardiovascular function; regeneration and degeneration in CNS; neurobiology of central monoamine neurons
W. F. Riker, Jr.: pharmacology and physiology of neuromuscular transmission
W. N. Schoenfeld: effects of long-term stress on selected behavioral and physiological systems, reinforcement schedules, behavior theory
J. Sechzer: visual learning and memory in adult and neonatal split-brain animals, learning and memory in split-brain animals
G. Smith: feeding behavior, emotional behavior, and learning in rats and monkeys, utilizing concepts of neuroendocrinology
P. Stokes: endocrinology and psychobiology
J. M. S. Winterkorn: visual behavior and learning after brain lesions

Courses

1. Neuroscience This is the basic undergraduate medical course and is required of all major and minor candidates in the field. It is a broadly based course taught by members of the field and introduces the student to neuroanatomy, neurophysiology, and pertinent neurology. Third trimester. D. Brooks and B. Grafstein.

2. Neurobiology Elective Each year the field offers an elective course that considers various special aspects of neurobiology and behavior. In the past, the courses have examined in depth the synapse, developmental neurobiology, and the impact of the environment on the nervous system. Offered in the third trimester, two hours each week; hours to be arranged, four to twenty students. B. Grafstein and staff.

Pathology

Faculty

D. R. Alonso, C. G. Becker, P. G. Bullough, F. Daniels, Jr., J. W. Dougherty, J. T. Ellis, A. Kellner, R. C. Mellors, C. R. Minick, G. E. Murphy, C. K. Petito, A. M. Prince, C. A. Santos-Buch, L. B. Senterfit, M. Susin, M. E. Weksler

Field Representative

C. G. Becker, Department of Pathology, Room C-444, Medical College

Pathology is the study of the causes and mechanisms of disease processes. The purpose of a graduate program in pathology is to provide individuals with a baccalaureate or medical degree with basic knowledge of disease processes through study of the disciplines of anatomic and clinical pathology and by learning modern techniques of biological investigation. It is hoped that a student completing this program will have both the information and technical skills to make significant inquiries into the nature of disease processes and to bridge the gap between classical, descriptive pathology and such disciplines as biochemistry and molecular biology.

The graduate program in pathology includes the observation of diseases in their various forms at autopsy and in clinical laboratories and study and research in the areas of immunology and immunopathology, oncology, virology, cellular biology, and electron microscopy. It may also include study in advanced mathematics, physiology, biophysics, pharmacology, anatomy, cytochemistry and histochemistry, advanced biochemistry, genetics and microbiology.

New students are expected to have completed mathematics through integral calculus, chemistry through organic chemistry (although physical chemistry is recommended), basic physics and at least general biology. A reading knowledge of at least one for-

eign language is suggested but not required. For those students entering the program with baccalaureate degrees only, the Graduate Record Examinations, including the Aptitude Tests and the Advanced Test in biology or chemistry, are required.

Graduate students in pathology are required, as a beginning part of their program, to take the course in general and systemic pathology offered to second-year medical students. They must minor in at least one and not more than two other biomedical fields. Courses in biomathematics, biochemistry, genetics, and microbiology are also required. Additional courses not available at the Graduate School of Medical Sciences can be taken at neighboring institutions with approval of the Field of Pathology and the candidate's Special Committee.

Special interests of the Faculty

D. R. Alonso: cardiovascular pathology
C. G. Becker: cardiovascular and renal diseases; immunopathology; host-parasite relationships
P. G. Bullough: diseases and metabolism of bone
F. Daniels, Jr.: diseases of the skin
J. W. Dougherty: diseases of the skin
J. T. Ellis: electron microscopy; kidney disease; muscle diseases
A. Kellner: immunohematology; lipid metabolism; pathogenesis of arteriosclerosis
R. C. Mellors: studies in immunopathology relating to the role of viruses in autoimmune disease and leukemogenesis
C. R. Minick: pathogenesis of arteriosclerosis and hypertension; lipid metabolism; immunopathology; electron microscopy
G. E. Murphy: cardiovascular diseases; host-parasite relationships
C. K. Petito: neuropathology; ultrastructure and histochemistry of diseases of central nervous system
A. M. Prince: virology; pathogenesis of liver diseases
C. A. Santos-Buch: cellular biology; immunopathology; cardiovascular disease; electron microscopy
L. B. Senterfit: antigenic structure of mycoplasma; pathogenesis of respiratory viral and mycoplasmic disease; vaccine development; clinical microbiology
M. Susin: pathology of renal disease; electron microscopy
M. E. Weksler: lymphocyte interactions with autologous cells in autoimmune and neoplastic diseases; immunology in aging

Courses

1. General and Systemic Pathology Lectures, practical classes, and seminars. First trimester: M W F 9-1. Second trimester: M W 10-1, Th 9-1. The staff.

2. Correlative Pathology Gross and microscopic material is correlated and related to the disease processes. The staff.

3. Forensic Pathology Courses are offered by special arrangement with the chief medical examiner of New York City.

4. Seminars in Pathology Discussions outlining the scope of modern pathology are given weekly. These include reports on original research by members of the staff and by visiting lecturers. Hours to be arranged. The staff.

5. Experimental Pathology Independent research projects in various areas of pathology are offered. The staff.

Related courses The following courses are offered by various members of the field in collaboration with faculty members of related fields. The terms and hours are by arrangement.

Immunopathology
Cardiovascular Pathology
Autopsy Pathology
Orthopedic Pathology
Renal Pathology
Gastrointestinal Pathology
Neuropathology
Surgical Pathology
Cytopathology
Tumor Pathology
Clinical Biochemistry
Hematology and Immunochematology
Clinical Microbiology

Pharmacology

Faculty

T. Baker, B. Berkowitz, J. J. Burns, W. W. Y. Chan, D. E. Drayer, R. W. Houde, C. E. Inturrisi, B. Jones, R. F. Kaiko, H. Kutt, R. Levi, M. Okamoto, G. W. Pasternak, M. M. Reidenberg, A. Rifkind, W. F. Riker, Jr., H. H. Szeto

Field Representative

M. Okamoto, Department of Pharmacology, Room E-411, Medical College

The graduate program emphasizes sound basic training in general pharmacology. Then, by means of individual instruction, the candidate receives exposure to several specialized aspects of pharmacology. The latter part of the graduate curriculum is devoted to research in an area of the candidate's choice.

An adequate preliminary training in organic chemistry, physical chemistry, biochemistry, and physiology is prerequisite to graduate work in pharmacology. Training in statistics is strongly recommended.

Special interests of the Faculty

T. Baker: neuropharmacology; neuromuscular transmission
B. A. Berkowitz: biochemical pharmacology; catecholamines; immunopharmacology of narcotics
J. J. Burns: biochemical pharmacology; drug metabolism
W. W. Y. Chan: renal pharmacology; endocrine pharmacology; polypeptide pharmacology
D. E. Drayer: drug metabolism

R. W. Houde: clinical pharmacology of the analgesic drugs; development of methods of evaluating the effects of drugs on subjective response
C. E. Inturrisi: biochemical pharmacology; metabolism of narcotic response
B. Jones: clinical pharmacology, chemotherapy of neoplastic diseases
R. F. Kaiko: clinical pharmacology of analgesic drugs
H. Kutt: clinical pharmacology, neuropharmacology; drug metabolism
R. Levi: cardiovascular pharmacology and electrophysiology; immunopharmacology
M. Okamoto: neuropharmacology; neuromuscular transmission; sedative-hypnotic drug dependence
G. W. Pasternak: molecular pharmacology, narcotic drug receptors
M. M. Reidenberg: clinical pharmacology; drug metabolism
A. Rifkind: clinical pharmacology; endocrine pharmacology
W. F. Riker, Jr.: general pharmacology; neuropharmacology; neuromuscular transmission
H. H. Szeto: fetal pharmacology, drug metabolism

Courses

1. General Pharmacology The basic pharmacology course is offered to second-year medical students and to qualified graduate students. It consists of lectures, laboratory work, demonstrations, and seminars given during the first and second trimesters. The purpose of these exercises is to teach the principles of pharmacology. Detailed consideration is given to the parameters of drug action to provide the student with the fundamental concepts essential for the evaluation of any drug. Consequently, the scientific basis of pharmacology is emphasized. Prototype drugs, essentially considered systemically, serve to illustrate several mechanisms and parameters of drug action. Therapeutic applications are considered only insofar as they illustrate principles of pharmacology or drug hazards. Prerequisites: biochemistry and physiology. The staff

2. Molecular Pharmacology Fundamental principles governing the effects of chemicals on living systems are examined from the viewpoint of drug-receptor interactions. Several concepts are introduced including drug selectivity, specificity dose-response, and receptor theory. Examples of receptor isolation and receptor-drug interactions are discussed in detail. Prerequisites: an adequate background in biology, organic and physical chemistry, and biochemistry is required. The staff and invited lecturers.

3. Research in Pharmacology Research opportunities may be arranged throughout the year for graduate students who are not majoring in pharmacology but who want some investigative experience in the discipline. Special opportunities are offered for work on the nervous and cardiovascular systems and in biochemical and clinical aspects of pharmacology. The staff

4. Advanced courses and seminars The Field of Pharmacology offers several advanced courses and seminars in areas of interest to the faculty and graduate students of the field. Seminars in clinical pharmacology and teaching rounds are held regularly throughout the year. The content, format, and schedule of these courses are determined each year on the basis of the number and the backgrounds of the interested students. The staff.

Physiology

O. S. Andersen, W. A. Briscoe, W. W. Y. Chan, T. J. Colatsky, P. W. Curreri, C. Fell, G. Frindt, D. Gardner, B. Grafstein, R. L. Greif, E. Heinz, N. B. Javitt, C. Lee, R. Levi, M. Lipkin, T. N. Maack, T. G. Pickering, E. M. Rabellino, E. E. Windhager

Field Representative

T. M. Maack, Department of Physiology and Biophysics, Room D-407, Medical College

Opportunities are offered toward the Ph.D. degree in several areas of physiology and biophysics. Ample space is available, and laboratories are well-equipped to provide predoctoral training in a medical environment. Interested individuals are urged to contact the field representative before preparing a formal application. Letters of inquiry should include a discussion of educational background and indicate possible areas of emphasis in graduate study. There has been a tendency to encourage applications from individuals who have a probable interest in one or more of the areas of physiology represented within the field.

Formal applications should include full college transcripts and at least two letters of recommendation. Graduate Record Examination scores are mandatory, since performance in these examinations is an important factor in the selection of applicants. Introductory courses in biology, inorganic and organic chemistry, physics, and mathematics through the level of differential and integral calculus are required. Additional course work in these disciplines at the undergraduate level is encouraged. Applicants with otherwise exemplary records who lack certain course requirements will be considered for acceptance provided that they remedy their deficiencies while in training.

The course of study emphasizes the importance of teaching and research in the preparation and development of individuals for careers in physiology. This goal is achieved by a combination of didactic courses, seminars, and closely supervised research leading toward the preparation of a satisfactory thesis.

A special program of study will be developed for each student in consultation with his or her Special Committee. In addition to the general requirements set by the Graduate School for all fields, all candidates for the doctoral degree in physiology will be expected to meet the following specific requirements:

1. Evidence of a satisfactory background in neurosciences. Ordinarily, the course in neuroscience described under the Field of Neurobiology and Behavior, or an equivalent course, will be taken concurrently with the course in physiology and biophysics.
2. Satisfactory completion of the course in physiology and biophysics, or an equivalent course.

3. For majors and minors in the field, a minimum of two elective courses in the field ordinarily will be required, in addition to the course in physiology and biophysics.
4. Proficiency in reading scientific literature in one modern foreign language.
5. Satisfactory completion of an individualized laboratory experience in an area of research different from that chosen for the doctoral dissertation.

Special Interests of the Faculty

O. S. Andersen: properties of cell membranes, artificial lipid membranes
W. A. Briscoe: blood gas transfer in health and disease
W. W. Y. Chan: pharmacology of neurohypophysial hormones and related polypeptides
T. J. Colatsky: cardiac electrophysiology
P. W. Curreri: physiology and pathophysiology of thermal injury
C. Fell: cardiovascular function, particularly blood flow distribution, blood volume, and blood volume distribution
G. Frindt: renal electrolyte metabolism; isolated perfused tubules
D. Gardner: neurophysiology
B. Grafstein: nerve regeneration and transport of materials in nerve axons
R. L. Greif: physiology of the thyroid gland and its secretions
E. Heinz: membrane transport; active transport
N. B. Javitt: gastrointestinal and hepatic physiology and pathophysiology
C. Lee: cardiac electrolyte physiology
R. Levi: heart electrophysiology; heart hypersensitivity reactions; histamine in cardiac function
M. Lipkin: proliferation and differentiation of normal and diseased gastrointestinal cells
T. M. Maack: protein transport and metabolism by the kidney
T. G. Pickering: cardiovascular physiology and pathophysiology
E. M. Rabellino: expression of membrane receptors and antigens in differentiating blood cells
E. Windhager: renal electrolyte metabolism

Courses

Students who plan to register for the course Physiology and Biophysics must consult the field representative before the start of the second trimester. Students who want to take any of the third-trimester courses (numbered 2-8) are advised to consult the field representative no later than the seventh week of the second trimester in order to assure a place in the course.

1. Physiology and Biophysics Lectures and conferences in body fluids, bioelectric phenomena, circulation, respiration, and gastrointestinal function. Second trimester, four hours each week. The staff.

Lectures and conferences on kidney function, acid-base regulation, endocrinology, and metabolism; and a weekly laboratory on selected aspects of physiology. Third trimester, eleven hours each week. The staff.

2. Respiratory and Renal Mechanisms of Regulation of Acid-Base Balance Each session consists of an informal lecture and a succeeding seminar discussion based on assigned reading in the area of the lecture. Third trimester: three hours each week. Five to fifteen students.

3. Selected Topics in Endocrinology Important scientific papers dealing with certain aspects of endocrinoogy are distributed to the participants one week in advance of discussion. Each paper is considered in detail in a seminar directed by an investigator in the area under discussion. One or two preliminary orientation sessions are given by Professor Greif before distribution of the first scientific paper, and, if feasibe, one or two laboratory days are planned. Third trimester three hours each week. Six to twelve students. R. L. Greif and staff.

4. Selected Topics in Gastrointestinal and Hepatic Physiology and Pathophysiology Topics include bilirubin metabolism and excretion, cholesterol metabolism, bile salt excretion, bile formation, esophageal motility, gastric function, intestinal cell turnover, absorption of fat, absorption of carbohydrate, the malabsorption syndrome. Third trimester: two hours each week. Six to twelve students. N. B. Javitt.

5. Selected Topics in Respiratory Physiology Topics covered include: (1) physiological anatomy of the lung; (2) logical formulation and solution of clinical problems; (3) ventilation, alveolar air diagram, nitrogen washout; (4) relevant lung function tests; (5) lung volumes, effect of posture and disease, (6) diffusion, Fick equation, Bohr integration; (7) acid-base considerations in blood, (8) mechanical properties of lung; (9) ventilation-perfusion ratio and Bohr integral isopleths; (10) ecology, sealed spaces, altitude, diving; (11) lung function in the first week of life. Students who want to take this course must consult Professor Briscoe no later than the seventh week of the second trimester. Third trimester: two hours each week. Maximum of twelve students. W. A. Briscoe.

6. Selected Topics in Kidney and Electrolyte Physiology and Pathophysiology Lectures, seminars, and demonstrations. Topics include: (1) GFR, clearance concept, reabsorption and secretion of electrolytes; (2) concentrating mechanism; (3) electrophysiology of the nephron; (4) pathyphysiology of potassium; (5) renal blood flow and its intrarenal distribution, (6) renal physiology in the newborn, (7) control of body fluid volume and tonicity; (8) pathology of renal failure: urinary sediment; pathophysiology of renal failure; (9) radiology of the kidneys, (10) dialysis, (11) transplantation. Third trimester: two hours each week. Maximum of twelve students. E. Windhager and staff.

7. Special Topics in Cardiovascular Physiology Original research papers will be made available in advance of each session, and these and the general problems associated with each topic will serve as the basis for the discussion. Insofar as possible, experimental approaches to each problem will be demonstrated. To some extent, choice of topics can be

determined by the interests of the group. Probable topics include: (1) regulation of peripheral blood flow; (2) integrated cardiovascular responses to hypoxia; (3) pulsatile flow in arteries; (4) measures of myocardial performance; (5) blood volume, hemorrhage, and hemorrhagic shock; (6) cardiac catherization in man, congenital heart disease, valvular heart disease. Third trimester: three hours each week. Six to twelve students. C. Fell.

8. Neurobiology Elective Described under courses offered by the Field of Neurobiology and Behavior.

Interdisciplinary Program in Molecular Medicine

This program offers studies leading to the Ph.D. degree in an established field of the Graduate School of Medical Sciences (biochemistry, microbiology, pathology, pharmacology, physiology). Although formal course work is required, emphasis is placed on basic research directed toward the understanding of human disease as the molecular level. A major goal of the program is to emphasize interdisciplinary interactions and collaboration, and thus to broaden the scope of the research capabilities of participating students. Research opportunities exist in many areas, including those listed below. Entering students may work for short periods in several laboratories before beginning thesis research.

The curriculum of each student is planned to meet individual interests and needs. In addition to research and regular course work, graduate students, postdoctoral research fellows, research associates, and the faculty participate in informal seminars and discussion groups, conducted in cooperation with various departments of the Medical Center.

The graduate student works directly with a faculty sponsor in the sponsor's laboratory and is expected to complete a research thesis of high quality in a subject relating to the major field.

Representative Thesis Research Areas

Atherosclerosis, aging, blood coagulation, renal diseases, endocrine disorders, drug dependence, cerebral function, hypertension, skin disorders, lung surfactants, liver disease, obesity, hemoglobin diseases, pancreatitis, hemolytic diseases, and diseases of purine, amino acid, carohydrate, and lipid metabolism.

Faculty

C. G. Becker (pathology); J. S. Cornell (biochemistry); J. T. Ellis (pathology); G. F. Fairclough (biochemistry); B. Grafstein (physiology); R. H. Haschemeyer (biochemistry); C. E. Inturrisi (pharmacology); R. Levi (pharmacology); A. Meister (biochemistry); C. H. Minick (pathology); A. Rifkind (pharmacology); W. F. Riker, Jr. (pharmacology); A. L. Rubin (biochemistry); C. A. Santos-Buch (pathology); L. B. Senterfit (microbiology); R. L. Soffer (biochemistry); K. H. Stenzel (biochemistry); S. S. Tate (biochemistry); E. H. Windhager (physiology).

Instruction at the Sloan-Kettering Division

1. Graduate Seminar This weekly graduate seminar is offered each year and is attended by all first- and second-year students of the division. Two or three topics are selected for discussion each year. Topics are usually chosen from the following: carcinogenesis; nucleic acid and protein chemistry and biochemistry; chromosome structure and function; molecular biology; regulation; radiobiology; immunology; membranes; cell surfaces; mammalian and bacterial viruses. The discussion is carried principally by graduate students under the guidance of faculty members whose area of specialization coincides with the topic. From time to time outstanding authorities are invited as guest speakers. In addition, students in the third and later years of graduate study address the seminar on the progress being made in their thesis work.

2. Research Colloquia Discussions of research conducted by the faculty and literature reports by students.

3. Special Laboratory Programs Throughout the year students may spend time in research laboratories. Arrangements for laboratory rotation should be made with the major sponsor.

4. Introduction to Biohazards and Laboratory Safety All students are required to take by their second year the course of six basic lectures sponsored by the Sloan-Kettering Institute Institutional Biosafety Committee. The series covers general laboratory safety, the use of radioisotopes, carcinogens, primary and secondary barrier systems, contamination control, and hazards associated with research animals, and is supplemented by lectures on special topics given throughout the year. M. S. Zedeck and staff.

5. Special Topics Seminars and discussions by the faculty. Second and third trimesters.

6. Minor Projects Two minor projects involving one month of full-time study or three months of part-time study are required of all students. These projects are to be completed before a student stands for the Admission to Candidacy Examination.

Biochemistry

Faculty

N. W. Alcock, L. H. Augenlicht, I. Balazs, M. E. Balis, F. C. Bancroft, R. S. Bockman, E. Borenfreund, L. F. Cavalieri, C. Cunningham-Rundles, Z. Darzynkiewicz, Ann M. Dnistrian, D. B. Donner, J. D. Fissekis, M. Fleisher, J. J. Fox, A. Giner-Sorolla, S. Green, M. G. Hamilton, U. Hämmerling, P. J. Higgins, L. Kopelovich, W. Kreis, K. O. Lloyd, P. W. Melera, M. J. Modak, J. S. Nisselbaum, B. A. Otter, J. C. Parham, J. Roberts, B. H. Rosenberg, J. S. Salser, A. S. Schneider, M. K. Schwartz, G. C. Sen, M. R. Sherman, V. P. Skipski, M. Sonenberg, G. Stöhrer, P. P. Trotta, K. A. Watanabe, S. S. Witkin, L. C. Yip.

Unit Chairperson

U. Hämmerling, Sloan-Kettering Division, Kettering Laboratory, Room 321

Opportunities are available for advanced work and research in chemistry and metabolism, bio-organic chemistry, enzymology, hormone chemistry and action, and molecular biology.

Undergraduate requirements for a major in biochemistry include courses in inorganic chemistry, qualitative and quantitative chemistry, organic chemistry, physical chemistry, physics, general biology and mathematics (through calculus). Any of these requirements not completed at the undergraduate level must be completed during graduate study.

Graduate Record Examination scores in both the Aptitude Test (verbal and quantitative) and the Advanced Test in chemistry or biology are required.

Students electing biochemistry as a major or minor subject must complete the first term of the Graduate Biochemistry course and the Advanced Biochemistry course as minimal requirements. Two minor subjects are required.

Students may be required to take an oral qualifying examination. A written examination may be required at the discretion of the student's Special Committee. The Admission to Candidacy Examination is both written and oral.

The only language requirements are those imposed by the student's Special Committee.

Special Interests of the Faculty

N. W. Alcock: trace metals; parenteral nutrition
L. H. Augenlicht: transcriptional control, eukaryotes
I. Balazs: RNA characterization; transcription and translation in man-mouse cell hybrids
M. E. Balis: enzyme regulation; purine metabolism
F. C. Bancroft: regulation of gene expression in eukaryotes
R. S. Bockman: parathyroid action, hypercalcemia and carcinogenesis
E. Borenfreund: biochemical genetics; chemical carcinogenesis
L. F. Cavalieri: reverse transcriptase; macromolecules
C. Cunningham-Rundles: molecular aspects of immunity; HLA composition; B-cell receptors
Z. Darzynkiewicz: differentiation and carcinogenesis
A. M. Dnistrian: membrane composition and carcinogenesis
D. B. Donner: hormone action; cell surface regulation
J. D. Fissekis: structural and functional relationships of biomolecules
M. Fleisher: tumor-associated antigens; clinical chemical automation
J. J. Fox: development of antitumor and antiviral chemicals
A. Giner-Sorolla: synthesis of antitumor and antiviral chemicals; carcinogenesis
S. Green: isolation of tumor necrotizing factor, macrophage enzymes
M. G. Hamilton: eukaryotic ribosomes; characterization of nucleic acids and proteins
U. Hämmerling: differentiation of lymphocytes, immunochemistry of T- and B-cells
P. J. Higgins: comparative biochemistry of embryonic and neoplastic development
L. Kopelovich: chromosomal proteins, nucleic acids, and neoplastic transformation
W. Kreis: biochemical pharmacology; biochemistry of macromolecules
K. O. Lloyd: immunochemistry; melanoma and ovarian antigens
P. W. Melera: growth and differentiation; biochemistry of RNA
M. J. Modak: DNA polymerase; reverse transcriptase; oncogenic viruses
J. S. Nisselbaum: mechanism of enzyme activity; isozymes
B. A. Otter: synthesis of antitumor compounds
J. C. Parham: chemical carcinogenesis, photochemistry; synthesis of antitumor drugs
J. Roberts: enzyme therapy and nutritional deprivation of neoplasms
B. H. Rosenberg: mechanism and control of DNA synthesis
J. S. Salser: biochemical and immunological characteristics of enzymes
A. S. Schneider: neurohormone secretion and action at cell membrane receptors
M. K. Schwartz: antigens, hormones, and enzymes in cancer detection; automated clinical biochemistry
G. C. Sen: regulation of gene expression in eukaryotic cells
M. R. Sherman: mechanism of steroid hormone action
V. P. Skipski: lipid metabolism and malignancy
M. Sonenberg: mechanism of peptide hormone action; ligand control of membrane structure and function
G. Stöhrer: carcinogenesis and cell differentiation
P. P. Trotta: adenosine deaminase, growth and differentiation
K. A. Watanabe: synthesis of nucleoside antibiotics and antimetabolites
S. S. Witkin: carcinogenesis and embryogenesis
L. C. Yip: enzymes in purine metabolism, aging, carcinogenesis

Courses

1. Biochemistry The course and hours are described on p. 28 under Interdivisional Courses.

2. Advanced Biochemistry The course and hours are described on p. 28 under Interdivisional Courses.

3. Physical Methods The course and hours are described on p. 28 under Interdivisional Courses.

Biology

Faculty

J. Abbott, A. M. Albrecht, R. S. Anderson, K. Artzt, D. Bennett, J. L. Biedler, E. A. Boyse, H. E. Broxmeyer, R. S. Chaganti, P. L. Chello, J. W. Chiao, Y. S. Choi, T. C. Chou, R. G. Coffey, R. K. Cross, N. K. Day, E. deHarven, E. E. Descher, M. A. B. De Sousa, G. B. Dooher, B. Dupont, M. G. Eisinger, R. L. Evans, D. P. Evenson, R. B. Faanes, A. M. Feinberg, G. Fernandes,

E. Fleissner, J. E. Fogh, E. A. Friedman, P. J. Gomatos, R. A. Good, S. Gupta, J. A. Gurr, J. W. Hadden, E. C. Hahn III, W. D. Hardy Jr., Y. Hirshaut, M. Hoffmann, D. J. Hutchison, G. Incefy, A. J. Kenyon, Y. B. Kim, P. W. Kincade, G. C. Koo, I. A. Kourides, R. M. Krug, G. W. Litman, C. Lopez, B. M. Mehta, M. R. Melamed, V. J. Merluzzi, M. A. S. Moore, P. V. O'Donnell, H. F. Oettgen, L. J. Old, G. J. O'Neill, R. J. O'Reilly, R. N. Pahwa, S. G. Pahwa, R. H. F. Peterson, F. S. Philips, M. S. Pollack, O. Prakash, W. Prensky, P. Ralph, B. Safai, N. H. Sarkar, M. Scheid, T. M. Setcavage, J. Sethi, F. W. Shen, D. M. Silver, L. M. Silver, A. E. Silverstone, M. Siniscalo, F. M. Sirotnak, E. M. Smithwick, H. W. Snyder, Jr., M. Spiegelman, C. W. Stackpole, E. Stavnezer, J. Stavnezer, S. S. Sternberg, W. E. Stewart II, O. Stutman, P. Szabo, M. N. Teller, L. Thomas, J. S. Tung, S. S. Wachtel, N. T. Williams, M. S. Zedeck

Unit Chairperson

G. W. Litman, Sloan-Kettering Division, Walker Laboratory, Room 3083

The program in biology is oriented toward an understanding of factors that initiate control and modify growth and biological development. Opportunity is offered for advanced work and research in cell biology, cytology, genetics, immunology, microbiology, pharmacology, pathology, biostatistics, and virology.

Undergraduate prerequisites for a major in biology include courses in inorganic chemistry, organic chemistry, physics, mathematics (through calculus), and general biology or zoology or botany or microbiology. Physical chemistry is recommended. Any of these requirements not completed at the undergraduate level must be completed during the first year of graduate study.

Graduate Record Examinations in both the Aptitude Test (verbal and quantitative) and the Advanced Test in biology or chemistry are required.

Programs are determined individually on the basis of interest, training, and prior experience. Elective courses in basic medical sciences include those described for the Medical College. Formal graduate courses, seminars, and tutorials are arranged with the faculties of the Sloan-Kettering Division and the Medical College Division.

Students may be required to take a qualifying examination. All students are required to pass the Admission to Candidacy Examination and defend a thesis. A major and two minor subjects are also required. The student's Special Committee may require knowledge of a foreign language.

Special Interests of the Faculty

J. Abbott: differentiation and cell surface antigens
A. M. Albrecht: folate metabolism and transformation and control mechanisms
R. S. Anderson: phylogeny, immunity and cancer
K. Artzt: cell surfaces and tumorigenesis in early mouse embryogenesis
D. Bennett: developmental genetics and differentiation
J. L. Biedler: somatic cell genetics and oncogenic potential
E. A. Boyse: immunogenetics of the cell surface
H. E. Broxmeyer: regulatory mechanisms and hematopoiesis
R. S. Chaganti: cytogenetics and cancer
P. L. Chello: molecular therapeutics and pharmacology
J. N. Chiao: immunobiology and differentiation of T lymphocytes
Y. S. Choi: immunobiology-tumor and lymphoid cell interactions
T.-C. Chou: molecular pharmacology and enzymology
R. G. Coffey: regulatory and effector hormones
R. K. Cross: viral genetics
N. K. Day: comparative and developmental studies of the complement system
E. deHarven: ultrastructure of cells, viruses, and cell surfaces
E. E. Deschner: proliferation and differentiation of gastrointestinal epithelium
M. A. B. de Sousa: lymphocytic environment; normal and malignant lymphoid organs
G. B. Dooher: surface and fine structure analysis of mouse spermatozoa
B. Dupont: human immunogenetics
M. G. Eisinger: human wart virus studies
R. L. Evans: immunobiology of T cells; immunoregulatory and cytotoxic activities
D. P. Evenson: ultrastructure of RNA and DNA and RNA tumor virus
R. B. Faanes: immunobiology; target cell-lymphocyte-antibody interaction
A. M. Feinberg: mechanisms of chemical carcinogenesis
G. Fernandes: nutrition; aging and immunity functions
E. Fleissner: molecular, biological, and immunological studies of murine leukemia viruses
J. E. Fogh: cancer cell biology and virology
E. A. Friedman: growth and differentiation of normal and preneoplastic cells
P. J. Gomatos: biochemistry and genetics of animal viruses and transformed cells
R. A. Good: immunobiology and cellular engineering
S. Gupta: primary and secondary immunodeficiencies; T-cell characterization
J. A. Gurr: thyroid stimulating hormone; regulation of gene expression
J. W. Hadden: immunopharmacology
E. C. Hahn III: virology; immunobiology; molecular biology of DNA replication
W. D. Hardy, Jr.: feline lymphosarcoma (leukemia)
Y. Hirshaut: human tumor antigens
M. Hoffmann: regulation of humoral immunity
D. J. Hutchison: microbiology; drug resistance and cytoregulation
G. Incefy: lymphocyte (T and B cells) differentiation
A. J. Kenyon: pathogenesis of lymphoproliferative diseases
Y. B. Kim: ontogeny of immune systems and microbial toxins
P. W. Kincade: hematopoietic differentiation; immunoglobulins
G. C. Koo: immunogenetics of sperm
I. A. Kourides: hormonal regulation of thyroid stimulating hormone gene expression; β-Endorphin in pituitary hormone regulation, behavior, and analgesia
R. M. Krug: biochemistry of transcription, translation, and viral replication

G. W. Litman: immunoglobulins; malignant transformation and carcinogenesis
C. Lopez: immunopathology; herpes and slow viruses
B. M. Mehta: quantitative microbiology; genetics
M. R. Melamed: cytophysics and cytochemistry
V. J. Merluzzi: regulation of cytotoxic T cells
M. A. S. Moore: multipotential stem cells; granulopoiesis
P. V. O'Donnell: characterization of murine leukemia viruses; surface antigens and peptide analysis of glycoproteins
H. F. Oettgen: cellular immune reactions
L. J. Old: cancer immunology and immunotherapy
G. J. O'Neill: immunogenetics; human complement
R. J. O'Reilly: microbial immunology
R. N. Pahwa: human T-cell differentiation
S. G. Pahwa: human B-cell differentiation
R. H. F. Peterson: malignancy; plasma membrane composition
F. S. Philips: pharmacology of antitumor and carcinogenic agents
M. S. Pollack: immunogenetics of human cell-surface alloantigens
O. Prakash: enzymology of reovirus replication
W. Prensky: molecular cytogenetics
P. M. Ralph: immunobiology; hematopoiesis, oncogenesis
B. Safai: pathology of skin
N. H. Sarkar: morphology of RNA oncogenic viruses
M. Scheid: regulation of T- and B-cell differentiation
T. M. Setcavage: ontogeny and regulation of immunity
J. Sethi: immunobiology; human sarcoma associated antigens
F. W. Shen: immunogenetics of the mouse
D. M. Silver: HLA-linked specifities; monoclonal antibodies and autoimmunity
L. M. Silver: molecular biology of development and embryogenesis
A. E. Silverstone: molecular biology of the initial phase of chemical carcinogenesis; DNA polymerases
M. Siniscalco: somatic cell genetics
F. M. Sirotnak: regulation; mutagenesis; transport and drug action
E. M. Smithwick: neutrophil function and metabolism
H. W. Snyder and murine leukemia surface proteins
M. Spiegelman: cell-cell interactions and embryonic development in mice
C. W. Stackpole: immunological and ultrastructural changes during differentiation and malignant transformation
E. Stavnezer: organization of eukaryotic genomes; regulation of RNA synthesis
J. Stavnezer: isolation and differentiation of immunoglobulin genes
S. S. Sternberg: pathology and drug toxicity
W. E. Stewart II: production and characterization of interferon; cloning of interferon mRNA
O. Stutman: cellular immunobiology; oncogenesis
P. Szabo; eukaryotic genome organization; molecular analysis of viral and host genome interactions
M. N. Teller: aging; immunology; oncogenesis
L. Thomas: microbial toxins and mycoplasma
J. S. Tung: biochemistry and immunogenetics of mouse cell surface antigens
S. S. Wachtel: immunogenetics
N. T. Williams: differentiation and maturation of hematopoietic stem cells
M. S. Zedeck: mechanisms of chemical carcinogenesis, biochemistry of antitumor drugs

Courses

1. Microscopic Anatomy This course is offered jointly by the Field of Biological Structure and Cell Biology of the Medical College Division and by the Biology Unit of the Sloan-Kettering Division. Details are given on p. 28 under Interdivisional Courses.

2. Microscopy for Cancer Research A laboratory course. An introduction to the morphology of cancer cells with a double emphasis: (1) *advanced methods in microscopy* and (2) *human cancer pathology*. Sessions consist of lectures and/or demonstrations, followed by a laboratory in which students will examine microscopic slides (microscopes will be provided). Methods of light microscopy (autoradiography, enzyme-cytochemistry, immunofluorescence, etc.), as well as electron microscopy (transmission, scanning, high resolution, etc.) emphasized. Approximately half of the sessions deal with the pathology of human neoplastic tissue (leukemia, breast cancer, hepatoma, etc.). Third trimester. E. deHarven, S. S. Sternberg, and staff.

3. Molecular Virology A formal course in which major emphasis is placed on the basic mechanisms in the biology of all animal viruses, including RNA and DNA tumor viruses. The topics considered include virus structure and composition, assay of viruses and viral-specific products; transcription and replication of viral nucleic acids; translation of virus-specific proteins; assembly of viral particles; structural and functional alterations in viral-infected cells including transformation; pathogenesis of viral diseases, and viral genetics. Second trimester. P. J. Gomatos, R. M. Krug, E. Fleissner, M. Modak, and staff.

4. Tumor Virology and Immunology A lecture and discussion course designed to give the student an in-depth understanding of tumor-virus host interactions in tissue culture and in animal systems. Both RNA and DNA tumor viruses are considered, especially leukemia-sarcoma viruses of mice, cats, and other mammals, mouse mammary tumor virus, and polyoma and SV40 viruses. Topics covered include inheritance of viral genes and genetic loci affecting virus expression, defective and recombinant viral genomes as oncogenic agents, transformed cell phenotypes and virus-coded transforming functions, tumor antigens and host immune responses, and viral proteins as tissue-specific differentiation antigens. The overall aims are to show (1) how viral and host genetic elements interact in the formation of specific gene products leading to cellular transformation and to tumor growth or rejection and (2) how such an analysis of neoplastic cells can clarify certain aspects of normal growth control and differentiation. Third trimester. E. Fleissner and staff.

5. Fundamentals of Cell Biology An interdisciplinary course designed to explore at a fundamental

level those aspects of cellularity with regard to the interaction between cells and their environment. The main purpose is to compare the way in which prokaryotic cells, unicellular organisms such as protozoa, constitutive eukaryotic cells of multicellular organisms, and cells in tissue culture react to and upon their environment. Comparisons will be made at the morphological, biochemical, biological and molecular levels. There will be discussions of cell replication, modes of expression of the cellular genome, and their regulation. Intercellular as well as intracellular controls of biochemical activities (e.g., DNA, RNA, and protein synthesis) and aspects of embryogenesis and histodifferentiation will be emphasized. Two-hour classes will be given by members of the faculty and by invited guest speakers and will include one half hour of discussion. Second trimester. E. deHarven and staff.

6. Cell Culture Techniques Short-term course in tissue culture techniques for a limited number of students at the Walker Laboratory in Rye. Each course, with two students in attendance, will run for a two week period.

The course work will include the theoretical and practical aspects of tissue culture with demonstrations and practice. It will cover general and special techniques as they apply to various fields of cancer research. Methods of prevention and detection of tissue culture contaminants will be demonstrated. J. Fogh.

7. Genetics Seminar Described on p. 14 under the Field of Genetics.

8. Advanced Immunology Described on p. 28 under Interdivisional Courses.

Biostatistics

Faculty

D. W. Braun, Jr., N. L. Geller, M. L. Lesser, V. Miké, H. T. Thaler

Unit Chairperson

V. Miké, Sloan-Kettering Division, Schwartz Hall, Room 724

Graduate work is offered leading to the Ph.D. degree in biostatistics. The program is designed to provide strong training in statistical theory and methodology and in statistical computing, combined with broad experience in data analysis and in collaborative research with biomedical investigators.

For admission to the program an applicant must have a baccalaureate degree in mathematics, statistics, or the equivalent. Graduate Record Examination scores in both the Aptitude Test (verbal and quantitative) and the Advanced Test in mathematics are ordinarily required. The student is expected to take the courses recommended by the Special Committee, satisfy two minor field requirements, participate in an internship program, and complete a dissertation. A written qualifying examination and the Admission to Candidacy Examination must be passed. There is no foreign language requirement, but proficiency in at least one computer programming language is expected.

Formal course work covers probability theory, statistical inference, and statistical computing. There is special emphasis on the design and analysis of clinical trials, and the development of skills in exploratory data analysis. The configuration of courses to be completed by each student will be determined by the Special Committee, after consideration of the student's academic background and research interests.

For the two minor fields the student may select from computer science, advanced probability, biomathematics, genetics, pharmacology, or any other area of study offered by the Graduate School of Medical Sciences. These minor fields may afford the student an opportunity to spend time working in a biological research laboratory.

Each student participates in an internship program in statistical consulting and collaborative research. General consulting is an important aspect of the work of a professional biostatistician. The student initially sits in on consulting sessions, then begins taking on such assignments under faculty supervision. He or she may also become involved in long-term collaborative research projects. The internship schedule will be arranged for each student by the Special Committee.

A doctoral dissertation in statistics involves the development of new theory or methodology under the direction of a faculty adviser. In this program, the student also has the option of working jointly with a statistician and a biomedical investigator. The thesis is then developed in response to a problem under investigation at this medical center, and the student is expected to demonstrate an ability to master the issues pertaining to an area of research in which he or she has no prior training, by interacting with an established scientist. The main responsibility for thesis guidance, however, is always carried by the statistical sponsor.

Special Interests of the Faculty

D. W. Braun, Jr.: survival analysis; statistical computing; genetics
N. L. Geller: probability theory; nonparametric inference; data analysis
M. L. Lesser: nonparametric inference; clinical trials; epidemiology
V. Miké: robust inference; epidemiology; genetics
H. T. Thaler: applied probability; data analysis; statistical graphics

Courses

Note: Courses 1-3 will be given in 1980-81. Courses 4-8 will be given for the first time in 1981-82.

1. Biostatistics I: Introduction to Statistical Reasoning It is the aim of this course to help participants gain some insight into the theory underlying a probabilistic approach to the treatment of observational or experimental data, and to acquaint them with the most basic techniques of statistical analysis. First trimester. M. L. Lesser

2. Biostatistics II: Experimental Design and Curve Fitting Application of concepts introduced in Biostatistics I to the analysis of scientific data. Topics include: statistical design of experiments, analysis of

variance, correlation, and linear regression. Second trimester. D. W. Braun, Jr.

3. Exploratory Data Analysis Tabular and graphical representations of data; stem-and-leaf diagrams, box plots, multidimensional methods; data reduction; transformations and smoothing; resistant analyses of structured data; diagnostic use of residuals. Third trimester. Staff.

4. Probability Theory Discrete and continuous probability spaces; combinatorial analysis; random variables; distribution functions; independence and conditional probability; generating and characteristic functions; Markov chains; martingales; laws of large numbers; central limit theorems; measure theoretic concepts. Three trimesters.

5. Statistical Inference Nature of statistical inference; sampling, data collection, sampling distributions and hypothesis testing; Neyman-Pearson lemma, maximum likelihood, sufficiency, Bayesian inference; regression and analysis of variance, experimental design; distribution-free methods. Three trimesters.

6. Statistical Computing Introduction to scientific computing; high-level languages; mathematical and statistical software; data structures and data base management systems. Hands-on experience with modern computing equipment. Three trimesters.

7. Survival Analysis and Clinical Trials Parametric and nonparametric models of survival times, exponential and Weibull distributions; life-table and Kaplan-Meier estimates; design of randomized clinical trials, concomitant variables, stratification, sample size determination; 2- and k-sample techniques for censored data; generalized Wilcoxon and log-rank tests, Cox regression. Two trimesters.

8. Analysis of Categorical Data Two- and higher-way contingency tables; hypergeometric and multinomial distributions; approximate methods; logistic models; combination and comparison of contingency tables; binary regression. One trimester.

The following courses will be offered in subsequent years.

Advanced Statistical Inference
Advanced Statistical Computing
Stochastic Processes
Time Series Analysis
Linear Models

Biophysics

Faculty

L. L. Anderson, R. E. Bigler, J. Fried, A. Gelbard, E. W. Hahn, J. H. Kim, J. S. Laughlin, J. C. McDonad, D. W. Miller, W. G. Myers, G. A. Russ, B. Schmall, R. S. Tilbury, H. Weiss, L. Zeitz

Unit Chairperson

J. S. Laughlin, Sloan-Kettering Division, Schwartz Hall, Room SM-11

Graduate work is offered leading to the Ph.D. degree in biophysics and the M.S. degree in radiation physics. A candidate for the Ph.D. must have a B.A. or B.S. degree with a major in physics, or with a major in biology, chemistry, or mathematics and a minor in physics. A candidate for the M.S. must have a B.A. or B.S. in physics from a recognized university.

Graduate Record Examination scores in both the Aptitude Test (verbal and quantitative) and the Advanced Test in physics, mathematics, chemistry, or biology are required.

Undergraduate prerequisites for the Ph.D. candidate include courses in general physics, electricity and magnetism, mechanics, mathematics (through calculus), and thermodynamics, and acceptable laboratory experience in these subjects. Any of those requirements not completed at the undergraduate level must be completed during graduate study. Graduate course work required for the Ph.D. is flexible, depending upon the student's background and basic interests, but ordinarily would include advanced courses in areas of physics, biology, biochemistry, and mathematics and courses in the student's minor subjects. In addition, a month spent full time on a laboratory project is required in each of the two minor disciplines.

Students may be required to pass a qualifying examination covering various basic aspects of their major and minor subjects and must pass the Admission to Candidacy Examination. The thesis required for the Ph.D. in biophysics should demonstrate the ability of the student to make a thorough and original investigation in an important area of biophysics. There is no mandatory foreign language requirement.

Some of the research projects in biophysics that are pertinent to the Ph.D. program incude: methods of production of radionuclides using a biomedical cyclotron, synthesis of labeled compounds, and their use for *in vivo* metabolic studies; the mechanism of radiation action on bacteria and small animals, including metabolism studies with human and other tumors influenced by radiation under different environmental conditions; fundamental radiobiological studies of mammalian cells in tissue culture and study of the early radiation-induced processes in cells using high-intensity pulsed irradiation techniques; effects of chemotherapeutic agents on cell survival and progression through the cell cycle; application to the treatment of human leukemia; the measurement of radiation by calorimetric, chemical, and solid-state techniques; the measurement of bone mineral content in the human.

A candidate for the M.S. must have a B.A. or B.S. in physics from a recognized university and have completed undergraduate courses in general physics, mechanics, electronics, electricity and magnetism, modern physics, and mathematics through differential equations. The candidate is expected to satisfactorily pass courses selected from some of the following subjects: physics, biophysics, biology, radiobiology, bio-

chemistry, and biomathematics and must minor in one of those subjects other than physics. The thesis subject must be in the field of radiation physics and must represent a comprehensive study demonstrating a thorough knowledge of the chosen subject. A final oral examination will be given, primarily on the subject of the thesis, and may be preceded by a written examination covering the fundamental principles of the course work. There is no mandatory foreign language requirement.

The course of study leading to the M.S. degree in radiation physics trains physicists in the various aspects of production, measurement, and application of radiation to various medical and biological problems. These problems particularly involve the use of radiation in the diagnosis and treatment of cancer. A variety of radiation sources is available, capable of generating photons and electrons with energies ranging from 5 Kev to 25 Mev and with electron dose-rates up to 10^{14} rads per second. Experience also is provided in the handling and use of many different radioisotopes. The magnitude and variety of facilities and unique radiation projects at the Sloan-Kettering Institute and the Memorial Hospital are particularly pertinent for training in this area. An important feature is the coexistence of fundamental research and practical and clinical applications in the same center.

Special Interests of the Faculty

L. L. Anderson: radiation dosimetry
R. E. Bigler: *in vivo* neutron activation analysis
J. Fried: cytotoxic agents and the cell cycle; flow cytofluorometry
A. S. Gelbard: enzymatic synthesis of compounds labeled with short-lived isotopes
E. W. Hahn: cytotoxicity of hyperthermia on normal and neoplastic cells
J. H. Kim: hyperthermia, radiation and drug actions on cell systems
J. S. Laughlin: metabolic studies with radionuclide labeled compounds
J. C. McDonald: radiation therapy; mechanisms of action
D. W. Miller: radiation dosimetry for diagnostic x rays
W. G. Myers: radiopharmaceuticals; history of nuclear medicine
G. A. Russ: chemistry and metabolism of short-lived labeled compounds
B. Schmall: syntheses and use of radiopharmaceuticals
R. S. Tibury: radiopharmaceuticals for use in nuclear medicine
H. Weiss: fast time processes in biophysics and radiobiology
L. Zeitz: mechanisms of damage and repair in mammalian cells

Courses

1. Radiological Physics Lectures and problems. A series of hourly lectures and assigned problems in applied mathematics, fundamentals of radiation physics, x-ray and radium treatment planning, diagnostic x-ray principles, radiation protection, and uses of radioactive isotopes. Hours by arrangement.

2. Radiobiology A semester course in fundamental radiobiology dealing with the effects of radiation on cells, viruses, and macromolecules, as well as on whole animals. The course also covers areas of radiation physics and radiation chemistry pertinent to radiobiology.

3. Advanced Biophysics Laboratory courses in each of the topics of radiation biophysics. Hours by arrangement.

4. Radiopharmaceutical Chemistry A tutorial course in radiopharmaceutical chemistry is offered for those students majoring or minoring in this subject. Hours by arrangement.

5. Biophysics Colloquia Reports on research in progress by faculty and outside lecturers. Required for majors in biophysics. Hours by arrangement.

Interdivisional Courses

1. Biochemistry Offered by the staff of the Field of Biochemistry, Medical College Division, and of the Biochemistry Unit, Sloan-Kettering Division. This course is designed to provide the student with a knowledge of the fundamentals of biochemistry and an appreciation of the molecular basis of biological phenomena. Graduate students in biochemistry are required to pass this course (or its equivalent) before pursuing advanced courses. Fall and winter trimesters. M T Th F 11–12. S. S. Tate, P. P. Trotta, and staff.

2. Advanced Biochemistry A course offered jointly by the faculties of the Medical College and Sloan-Kettering Divisions. The course consists of a series of lecture units (minicourses) covering topics such as: size, shape, and structure of macromolecules; molecular biology; information transfer; membrane structure and function; hormones; enzyme structure and function; antimetabolites in chemotherapy; and other subjects of current research interests. These subjects are taught at an advanced level with particular attention to contributions of recent research. It is not essential that students take the lecture units in any particular sequence. Minimal prerequisite: Biochemistry (described above) or its equivalent. Winter and spring trimesters. L. H. Augenlicht, J. Parham, S. S. Tate, and staff.

3. Physical Methods This course consists of a series of workshops including laboratory demonstrations and lectures and/or tutorials in physical techniques for the study of macromolecular and cellular structure. Examples of techniques available for study are: hydrodynamic and equilibrium methods, electron microscopy and other optical methods, resonance methods, and separation techniques such as chromatography, electrophoresis, isoelectric focussing, affinity methods. Time and place must be arranged with the faculty members in charge. Prerequisites: Biochemistry or its equivalent and Physical Chemistry. First trimester. R. H. Haschemeyer, M. G. Hamilton, P. P. Trotta, and staff.

4. Advanced Immunology Lectures, discussions, and assigned readings cover properties of antigens and antibodies; mechanism of antibody formation; phylogeny and ontogeny of the immune system; structural and functional aspects of the immune system; effector mechanisms of antibody- and cell-mediated immunity; complement and other amplification systems; mechanisms of immune injuries; regulation and control of the immune response; genetics and immunology of transplants and tumors. Laboratory work will include the isolation, purification, quantitation, and characterization of antibodies; the critical measurement of antigen-antibodies reactions, and the dynamics of the *in vivo* antibody response. Minimal prerequisites for lecture and laboratory courses: at least one semester or equivalent of biochemistry; introductory immunology (such as the immunology section, taught each September, of Microbiology and an Introduction to Infectious Diseases, Field of Microbiology). Next offering of laboratory courses to be announced. D. H. Sussdorf. Lecture course offered during second and third trimesters in 1980-81, two lectures weekly. Second trimester: Y. B. Kim and staff. Third trimester: D. H. Sussdorf and staff.

5. Microscopic Anatomy Offered by the staff of the Field of Biological Structure and Cell Biology, Medical College Division, and of the Biology Unit, Sloan-Kettering Division. This course follows a cellular and differentiative approach aimed at understanding the structure-function correlates that characterize the different tissues and organs. Selected topics are presented in the lectures and laboratory exercises to indicate a pattern of study and depth of analysis that the student can be expected to apply to the study of cells and tissues. A microscope slide collection, presenting tissues and organs in a variety of physiological and developmental states, as well as correlative electron micrographs are provided for individual study in the laboratory. Students must provide their own compound microscopes through their departments or sponsors. First and second trimesters. Lectures: T Th 10-11, F 9-10. Laboratory: T Th 3-5. R. F. Bachvarova, G. B. Dooher, J. J. Rasweiler, M. Spiegelman.

Special Programs

Ph.D.-M.D. Program

Students enrolled in the Graduate School of Medical Sciences may be eligible for admission into the Ph.D.-M.D. Program, jointly sponsored by the Medical College and the Graduate School of Medical Sciences. This program is designed for those few graduate students whose teaching and research goals require the acquisition of the M.D. degree in addition to the Ph.D. degree. The program is *not* designed as an alternate path for students who have the M.D. degree as their primary goal, but who have not been accepted by a medical school. Those who know, at the time of application to Cornell, that they want to pursue a course of study leading to both degrees should apply to one of the M.D.-Ph.D. programs of the Medical College described below. Only students enrolled in the Graduate School of Medical Sciences, or accepted for enrollment, may apply for admission to the Ph.D.-M.D. program at Cornell University Medical College.

Requirements for Admission

Applications to this program are ordinarily made after completion of the first year of study in the Graduate School of Medical Sciences, although more advanced students may be considered. The deadline for application is July 1.

To apply, the student must submit to the Ph.D.-M.D. Committee of the Graduate School of Medical Sciences:
1. A completed application for admission with advanced standing to Cornell University Medical College (obtainable from the Medical College Admissions Office)
2. A plan of graduate study incorporating all required course work of the first two years of the Medical College curriculum and endorsed by the student's Special Committee
3. Evidence of successful completion of at least two major medical school basic science courses (anatomical sciences, biochemistry, microbiology, pathology, pharmacology, physiology)
4. Two letters of evaluation from faculty of the Graduate School of Medical Sciences

The Ph.D.-M.D. Committee of the Graduate School of Medical Sciences will review the students' credentials and will select from among the applicants those students to be considered by the Committee on Admissions of Cornell University Medical College. Only applicants who are found to be acceptable for admission to Cornell University Medical College by its Committee on Admissions, after review of the application and a personal interview, will be accepted into the Ph.D.-M.D. Program. Final decisions will be made before August 15.

Degree Requirements

Students accepted in this program must fulfill the following requirements before admission to the third year clinical curriculum of the Medical College:
1. Complete all required graduate courses and the remainder of the first two years of the medical curriculum. The students must satisfy the academic requirements of the medical curriculum as these are determined by each of the departments of the first two years.
2. Pass the Admission to Candidacy Examination required by the Graduate School of Medical Sciences.
3. Complete the dissertation research, present and successfully defend an original thesis at the final examination for the Ph.D. degree.

After satisfactory fulfillment of the required clinical rotations of the Cornell third-year medical curriculum, these students may receive credit for their graduate studies to satisfy the elective requirements of the fourth-year medical curriculum and will then be recommended for award of the M.D. degree by Cornell University.

While registered as a graduate student in the Ph.D.-M.D. program the student is subject to the tuition

schedule of the Graduate School of Medical Sciences. Upon completion of the requirements for the Ph.D. degree, the student is registered in the Medical College and is subject to the tuition schedule of the Cornell University Medical College.

M.D.-Ph.D. Program

Programs of study leading to the Ph.D. degree are available to (1) students entering Cornell University Medical College, (2) medical students already matriculated at the Medical College, and (3) resident physicians in hospitals affiliated with the Medical College.

Entering Medical Students

The applicant to this program for entering medical students must apply to both the Cornell University Medical College and the Graduate School of Medical Sciences and be accepted through the admissions procedures of both schools.

The purpose of this program is to expose the student to both medical and graduate disciplines from the outset. The student spends the first two years as a medical student studying the basic medical sciences and attending regular graduate seminars. The summer months are spent in the laboratory learning experimental techniques and doing research. The third, fourth, and fifth years of the student's program are spent as a full-time graduate student and are devoted exclusively to laboratory research and writing the thesis. The sixth year of the program is spent as a medical student in clinical study. This six-year program represents the minimum time required to satisfy residence requirements of both the M.D. and Ph.D. degrees at Cornell University

Ordinarily an entering medical student accepted into the M.D.-Ph.D. program will initially register in both the Cornell University Medical College and the Graduate School of Medical Sciences. For the first and second years of the program, the student ordinarily will maintain registration as a full-time medical student. The student may accumulate residence credit in the Graduate School of Medical Sciences for full-time graduate study during the summer.

During the third and fourth years of the M.D.-Ph.D. program, a student ordinarily will be registered as a full-time graduate student. In general, a student will be registered in both the Cornell University Medical College and the Graduate School of Medical Sciences during the last year of study for the Ph.D., which in most cases will be the fifth year of the program. During the final year of the program, usually the sixth year, a student will be registered only in the Cornell University Medical College.

A student in the M.D.-Ph.D. program is liable for tuition to the school in which registered. During the year in which the student is registered in both the Cornell University Medical College and the Graduate School of Medical Sciences, the student will be liable for half the tuition to each school.

Matriculated Medical Students

A medical student enrolled in the Cornell University Medical College may interrupt medical studies at any time to pursue full-time graduate study leading to the Ph.D. degree. The student must fulfill all regular requirements of the Graduate School of Medical Sciences. A maximum of two residence credits for basic sciences course work taken in the medical curriculum can be granted toward the Ph.D. degree after the student passes an evaluation examination.

A medical student who elects to begin graduate work leading to the Ph.D. degree in the senior year of medical school may register in both the Cornell University Medical College and the Graduate School of Medical Sciences. The student begins his or her graduate didactic work during that year, and, ordinarily, the M.D. degree is granted at the end of that year. Research in the area of the Ph.D. thesis topic is begun during the fifth year. A two-year period of full-time research is a realistic minimum estimate for the time required to execute the experimental and theoretical work necessary to fulfill the requirements for the Ph.D. degree.

Resident Physicians

The resident physician may apply for admission to the Graduate School of Medical Sciences as a full-time graduate student working toward the Ph.D. Part-time graduate study is not permitted. A maximum of two residence credits for medical school course work in the basic sciences can be granted toward the residence requirements of the Ph.D. degree after the student passes an evaluation examination.

Prospective applicants to these programs should communicate with the dean of the Graduate School of Medical Sciences.

Register

University Administration

Frank H. T. Rhodes, President of the University
W. Keith Kennedy, University Provost
Thomas H. Meikle, Jr., Provost for Medical Affairs
William G. Herbster, Senior Vice President
W. Donald Cooke, Vice President for Research
William D. Gurowitz, Vice President for Campus Affairs
Robert T. Horn, Vice President, Treasurer, and Chief Investment Officer
Robert M. Matyas, Vice President for Facilities and Business Operations
Richard M. Ramin, Vice President for Public Affairs
Alison P. Casarett, Vice Provost
Larry I. Palmer, Vice Provost
James W. Spencer, Vice Provost
Walter J. Relihan, Jr., Secretary of the Corporation and University Counsel
Neal R Stamp, Senior Counsel to the University
Kenneth I. Greisen, Dean of the University Faculty

Graduate School of Medical Sciences

Administration

Frank H T. Rhodes, President of the University
Alison P. Casarett, Dean of the Graduate School
Julian R. Rachele, Dean of the Graduate School of Medical Sciences and Associate Dean of the Graduate School
Paul A. Marks, Director, Sloan-Kettering Division
Dorris J. Hutchison, Associate Director, Sloan-Kettering Division; Associate Dean of the Graduate School of Medical Sciences; Assistant Dean of the Graduate School

Faculty

Joan Abbott, Assistant Professor of Biology. B. A. 1954, Connecticut College; M.A. 1957, Washington University; Ph.D. 1965, University of Pennsylvania
Alberta M. Albrecht, Associate Professor of Microbiology. B.S. 1951, Seton Hall College; Ph.D. 1961, Rutgers University
Nancy W Alcock, Assistant Professor of Biochemistry B.S. 1949, University of Tasmania; Ph.D. 1960, University of London (England)
Fred H. Allen, Jr., Clinical Associate Professor of Pediatrics. A.B. 1934, Amherst College; M.D. 1938, Harvard University
Vincent G. Allfrey, Adjunct Professor of Genetics. B.S. 1943, City College of New York; M.S. 1948, Ph.D. 1949, Columbia University
Daniel R. Alonso, Associate Professor of Pathology M.D. 1962, University of Cuyo (Argentina)
Olaf S. Andersen, Associate Professor of Physiology Candidatus Medicinae 1971, University of Copenhagen (Denmark)
Lowell L. Anderson, Adjunct Assistant Professor of Biophysics. B.S. 1953, Whitworth College; Ph.D. 1958, University of Rochester
Robert S. Anderson, Assistant Professor of Biology B.S. 1961, Drexel University; M.S. 1968, Hahnemann Medical College; Ph.D. 1971, University of Delaware
Karen Artzt, Associate Professor of Biology A.B 1964, Ph.D. 1972, Cornell University
Leonard H. Augenlicht, Assistant Professor of Biochemistry. B.A. 1967, SUNY at Binghamton; Ph.D. 1971, Syracuse University
Rosemary F Bachvarova, Assistant Professor of Genetics. B.A. 1961, Radcliffe College; Ph.D. 1966, Rockefeller University
Thomas Baker, Assistant Professor of Pharmacology A.B. 1968, Hunter College; M.S. 1971, Cornell University
Ivan Balazs, Assistant Professor of Biochemistry Ph.D. 1972, Albert Einstein College of Medicine
M. Earl Balis, Professor of Biochemistry. B.A 1943, Temple University; Ph.D. 1949, University of Pennsylvania
F. Carter Bancroft, Associate Professor of Biochemistry B.S. 1959, Antioch College; M.A 1961, Johns Hopkins University; Ph.D. 1966, University of California at Berkeley
Carl G. Becker, Professor of Pathology B.S 1957, Yale University; M.D. 1961, Cornell University
J. Michael Bedford, Professor of Anatomy B.A 1955, M.A., Vet. M.B. 1958, Cambridge University (England); Ph.D. 1965, University of London (England)
Dorothea Bennett, Professor of Biology A.B. 1951, Barnard College; Ph D 1956, Columbia University
Barry A. Berkowitz, Adjunct Associate Professor of Pharmacology B.S 1964, Northeastern University, Ph.D 1968, University of California

June L. Biedler, Professor of Biology. A.B. 1947, Vassar College; Ph.D. 1959, Cornell University

Rodney E. Bigler, Assistant Professor of Biophysics. B.S. 1966, Portland State University; Ph.D. 1971, University of Texas

Ira B. Black, Associate Professor of Neurology. A.B. 1961, Columbia College; M.D. 1965, Harvard University

Richard S. Bockman, Assistant Professor of Biochemistry. B.A. 1962, Johns Hopkins University; M.D. 1967, Yale University; Ph.D. 1971, Rockefeller University

Ellen Borenfreund, Associate Professor of Biochemistry. B.S. 1946, Hunter College; Ph.D. 1957, New York University

Adele L. Boskey, Assistant Professor of Biochemistry. B.A. 1964, Barnard College; Ph.D. 1970, Boston University

Edward A. Boyse, Professor of Biology. M.B., B.S. 1952, M.D. 1957, University of London (England)

David W. Braun, Jr., Assistant Professor of Biostatistics. B.A. 1972, M.S. 1975, Ph.D. 1976, State University of New York at Buffalo

Esther M. Breslow, Professor of Biochemistry. B.S. 1953, Cornell University; M.S. 1955, Ph.D. 1959, New York University

William A. Briscoe, Professor of Medicine. B.A. 1939, M.A. 1941, B.M., B.Ch. 1942, D.M. 1951, Oxford University (England)

Dana C. Brooks, Professor of Anatomy. B.E.E. 1949, M.D. 1957, Cornell University

Hal E. Broxmeyer, Assistant Professor of Biology. B.S. 1966, Brooklyn College; M.S. 1969, Long Island University; Ph.D. 1973, New York University

Peter Bullough, Associate Professor of Pathology. M.D. 1956, Liverpool University (England)

John J. Burns, Adjunct Professor of Pharmacology. B.S. 1942, Queens College; M.A. 1948, Ph.D. 1950, Columbia University

Liebe F. Cavalieri, Professor of Biochemistry. B.S. 1943, Ph.D. 1945, University of Pennsylvania

R. S. K. Chaganti, Assistant Professor of Biology. B.S. 1954, M.S. 1955, Andhra University (India); Ph.D. 1964, Harvard University

Walter W. Y. Chan, Professor of Pharmacology. B.A. 1956, University of Wisconsin; Ph.D. 1961, Columbia University

Paul L. Chello, Assistant Professor of Biology. B.A. 1964, Johns Hopkins University; Ph.D. 1970, University of Vermont

Jen-Wei Chiao, Assistant Professor of Biology. B.S. 1966, Southwestern University; M.S. 1968, Ph.D. 1971, University of Illinois Medical Center

Yong S. Choi, Professor of Biology. M.D. 1961, Seoul National University (Korea); M.S., Ph.D. 1965, University of Minnesota

Ting-Chao Chou, Associate Professor of Pharmacology. B.S. 1961, Kaohsiung Medical College (Taiwan); M.S. 1965, National Taiwan University; Ph.D. 1970, Yale University

Ronald G. Coffey, Assistant Professor of Biology. B.S. 1958, Colorado State University; Ph.D. 1963, Oregon State University

Thomas J. Colatsky, Assistant Professor of Physiology. B.S. 1972, Georgetown University; Ph.D. 1977, State University of New York at Buffalo

Arthur J. L. Cooper, Assistant Professor of Biochemistry (Neurology). B.Sc. 1967, M.Sc. 1969, University of London (England); Ph.D. 1974, Cornell University

James S. Cornell, Assistant Professor of Biochemistry. B.S. 1969, Michigan State University; Ph.D. 1973, University of California at Los Angeles

Charlotte Cunningham-Rundles, Assistant Professor of Biochemistry. B.S. 1965, Duke University; M.D. 1969, Columbia College of Physicians and Surgeons; Ph.D. 1974, New York University

P. William Curreri, Professor of Surgery. A.B. 1958, Swarthmore College; M.D. 1962, University of Pennsylvania

B. Shannon Danes, Associate Professor of Medicine. B.A. 1948, Mount Holyoke College; M.A. 1949, University of Texas; Ph.D. 1952, State University of Iowa; M.D. 1962, Columbia University

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Vivian Risa Albert, B.A. 1979, M.S. 1980, Stanford University. Major: neurobiology and behavior. Los Angeles, California
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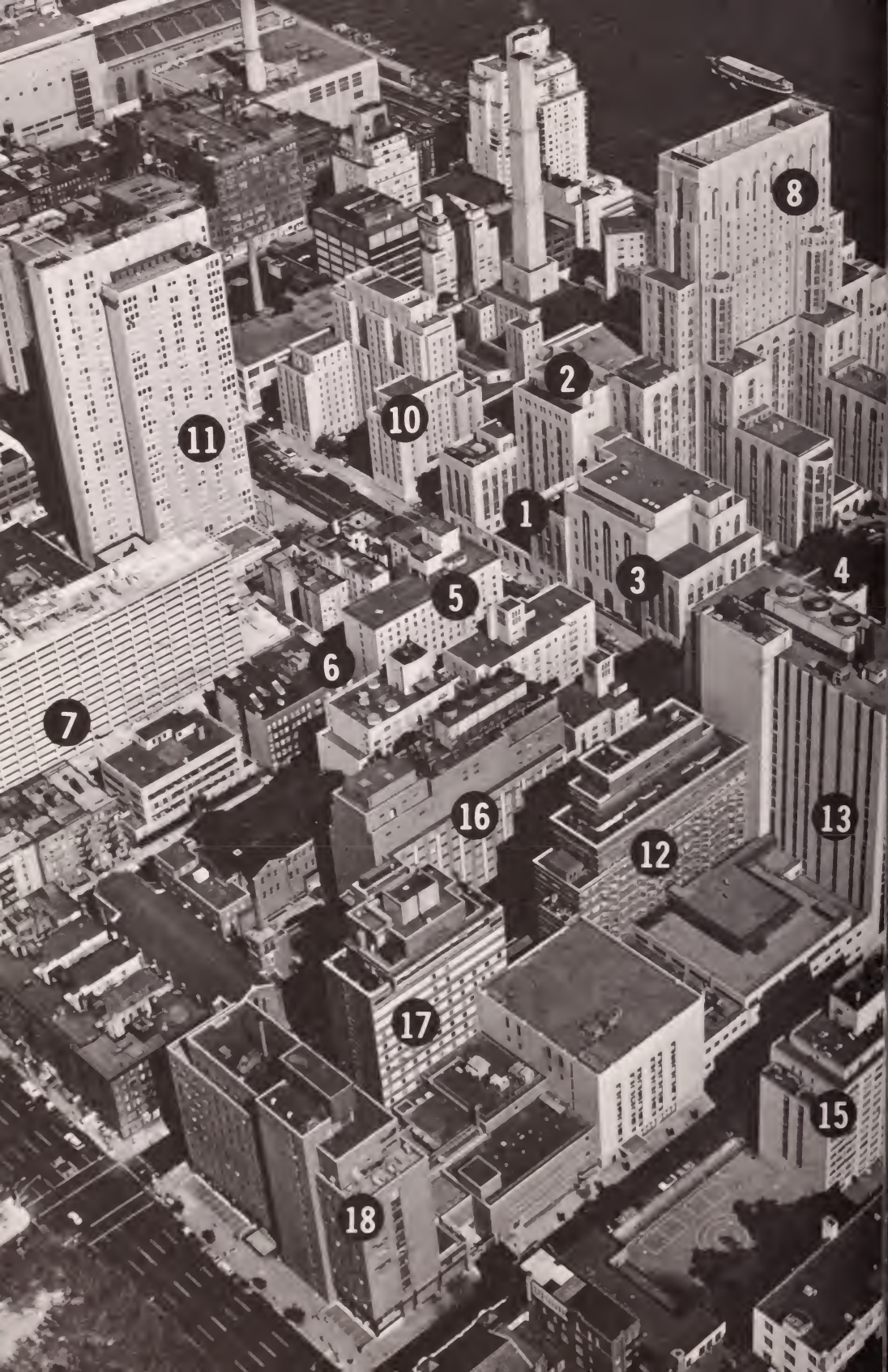
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Cornell University Medical College

1 Anatomy Building
2 William Hale Harkness
Medical Research Building
3 Samuel J. Wood Library
and Research Building
4 Biochemistry-Pharmacology Building
5 Olin Hall
6 Livingston Farrand Apartments
7 Lasdon House

The New York Hospital

8 The New York Hospital
9 Payne Whitney Psychiatry Clinic
10 Nurses' Residence
11 Payson House

Memorial Sloan-Kettering Cancer Center

12 Old Memorial Hospital Building
13 Memorial Hospital
14 Sloan House
15 Winston House
Sloan-Kettering Institute
16 Kettering Laboratory
17 Howard Laboratory
18 Arnold and Marie Schwartz International
Hall of Science

19 **Rockefeller University**

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In addition to the *Announcements* listed above, the University publishes a master catalog of University courses, *Description of Courses*, and a handbook for enrolled students, *Academic Information*.

Requests for the publications listed above should be addressed to
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